ADJACENT FIELD OPTICAL HEAD, WORKING METHOD THEREFOR AND OPTICAL RECORDING AND REPRODUCING DEVICE

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Inventor(s): ITOU AKITOMO; HOSAKA SUMIO; MURANISHI MASARU; NAKAMURA KIMIO
Applicant(s): HITACHI LTD
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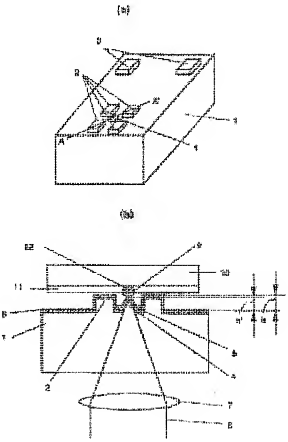
Abstract of **JP 11265520 (A)**

PROBLEM TO BE SOLVED: To provide a small-sized and light-weight adjacent field optical head in a simple constitution capable of increasing the relative speed of a recording medium and the optical head, and to provide an optical recording and reproducing device using the same. SOLUTION: On a slider 1, pads 2 provided so as to control the contact or floating state of the slider 1 and an information recording medium 11 and a probe 4 for generating an adjacent field light 9 of a fine spot size are mounted adjacent to each other. A semiconductor laser beam converged by an objective lens is converted to an adjacent field light 9 of the fine size near the tip of the adjacent field light generation probe 4. The slider 1 floats from a recording medium substrate 10 by several 10 nm and travels, and information 12 is recorded and reproduced to/from the recording medium 11 formed on the substrate 10 by the adjacent field light 9. Thus, this small-sized optical recording and reproducing device in a simple constitution of a super high recording density and a high transfer speed is constituted.



Family list
4 application(s) for: **JP11265520 (A)**

1. **ADJACENT FIELD OPTICAL HEAD, WORKING METHOD THEREFOR AND OPTICAL RECORDING AND REPRODUCING DEVICE**
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   EC: G01Q60/18; G11B7/12F; (+5) **IPC:** *G11B21/21; G01N13/10; G01N13/14;* (+17)
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2. **Near-field optical head and manufacturing method thereof and optical recording/readout system using near-field optical head**
   Inventor: ITO KENCHI [JP] ; HOSAKA SUMIO [JP] (+2) **Applicant:** HITACHI LTD [JP]
   EC: G01Q60/18; G11B7/12F; (+5) **IPC:** *G11B21/21; G01N13/10; G01N13/14;* (+14)
   Publication info: **NL1011471 (A1)** — 1999-09-20

3. **Near-field optical head and manufacturing method thereof and optical recording/readout system using near-field optical head**
   Inventor: ITO KENCHI [JP] ; HOSAKA SUMIO [JP] (+2) **Applicant:** HITACHI LTD [JP]
   EC: G01Q60/18; G11B7/12F; (+5) **IPC:** *G11B21/21; G01N13/10; G01N13/14;* (+14)
   Publication info: **NL1011471 (C2)** — 2002-05-01

4. **Near-field optical head and manufacturing method thereof and optical recording/readout system using near-field optical head**
   Inventor: ITO KENCHI [JP] ; HOSAKA SUMIO [JP] (+2) **Applicant:** HITACHI LTD [US]
   EC: G01Q60/18; G11B7/12F; (+5) **IPC:** *G11B21/21; G01N13/10; G01N13/14;* (+13)
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(54)【発明の名称】　近接場光ヘッド、近接場光ヘッドの加工方法および光記録再生装置

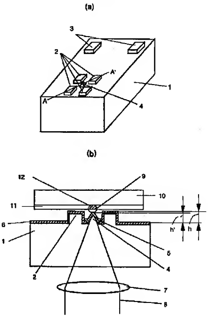
(57)【要約】

【課題】　記録媒体と光ヘッドの相対速度を大きくでき、かつ小型、軽量で簡略な構成の、近接場光ヘッドおよびそれを用いた光記録再生装置を提供すること。

【解決手段】　スライダ１の上に、スライダ１と情報記録媒体１１の接触ないし浮上の状態を制御するために設けられたパッド２と、微小なスポットサイズの近接場光９を発生させるプローブ４が、近接して設けられる。対物レンズで集光された半導体レーザ光は、近接場光発生プローブ４の先端付近で微小なサイズの近接場光９に変換される。スライダは、記録媒体基板１０より数１０ｎｍ浮上して走行し、前記近接場光９により、基板１０上に形成された記録媒体１１への、情報１２の記録、再生が行われる。

【効果】　超高記録密度でかつ転送速度の大きい、小型かつ簡素な構成の光記録再生装置を構成できる。

図1



【特許請求の範囲】
【請求項１】情報記録媒体と接触しつつ、またはほぼ一定の間隔を保ちながら相対運動をする光学的に透明なスライダと、前記情報記録媒体と対向する前記スライダの面上に設けられ、前記スライダと前記情報記録媒体の接触または浮上の状態を制御する柱状のパッドと、微小なスポットサイズの近接場光を発生させる錐体形状のプローブと、を有し、前記パッドと前記プローブが近接して設けられていることを特徴とする近接場光ヘッド。
【請求項２】前記プローブの高さが、前記パッドの高さより低いことを特徴とする請求項１記載の近接場光ヘッド。
【請求項３】前記プローブの上に光学的に不透明な薄膜が形成されていることを特徴とする請求項２記載の近接場光ヘッド。
【請求項４】前記光学的に不透明な薄膜が、金属であることを特徴とする請求項３記載の近接場光ヘッド。
【請求項５】前記パッドが前記プローブを囲むように配置されていることを特徴とする請求項４記載の近接場光ヘッド。
【請求項６】前記パッドが少なくとも複数の部分に分割されており、分割された部分の間隙を通して、前記プローブが鳥瞰されるように、前記パッドと前記プローブが配置されていることを特徴とする請求項５記載の近接場光ヘッド。
【請求項７】前記プローブの先端部分に、前記プローブの構成物が露出した開口をさらに有し、前記開口と前記金属薄膜の表面とがほぼ同一平面になっていることを特徴とする請求項５記載の近接場光ヘッド。
【請求項８】請求項４記載のプローブを加工する近接場光ヘッドの加工方法において、粒子ビームの照射によるエッチングにより錐体構造にプローブを加工することを特徴とする近接場光ヘッドの加工方法。
【請求項９】請求項４記載のプローブを加工する近接場光ヘッドの加工方法において、前記薄膜に粒子ビームを照射しエッチングすることにより、開口を形成することを特徴とする近接場光ヘッドの加工方法。
【請求項１０】請求項４記載の近接場光ヘッドと、前記近接場光ヘッドへ照射光を提供する光源と、光記録媒体と、前記近接場光ヘッドにより発生された近接場光の記録媒体による変調信号を検出する受光手段とを有することを特徴とする光記録再生装置。
【請求項１１】請求項１０記載の光記録再生装置において、前記プローブへの照射光を集光する手段、前記集光手段によって集光された照明光の焦点位置とプローブ位置のずれを検出する手段、および前記集光手段と前記プローブの相対位置を補正する可動機構を有することを特徴とする光記録再生装置。
【請求項１２】請求項１１記載の光記録再生装置において、前記集光手段と前記プローブとの相対位置を補正する可動機構と前記集光手段とが、光情報記録再生装置を構成する他の構成要素から分離され、前記集光手段を記録媒体の所定の位置にアクセスさせる可動機構上に搭載されていることを特徴とする光記録再生装置。
【請求項１３】情報記録媒体と相対運動をする光学的に透明なスライダと、前記情報記録媒体と前記スライダとの間隔を制御するパッドと、近接場光を発生する錐体形状のプローブと、を有し、前記パッドと前記プローブは前記情報記録媒体と対向する前記スライダの面上に接近して設けられていることを特徴とする近接場光ヘッド。
【請求項１４】前記プローブの高さが、前記パッドの高さより低いことを特徴とする請求項１３記載の近接場光ヘッド。
【請求項１５】前記プローブの上に光学的に不透明な薄膜が形成されていることを特徴とする請求項１４記載の近接場光ヘッド。
【請求項１６】前記光学的に不透明な薄膜が、金属であることを特徴とする請求項１５記載の近接場光ヘッド。
【請求項１７】前記パッドが前記プローブを囲むように配置されていることを特徴とする請求項１６記載の近接場光ヘッド。
【請求項１８】前記パッドが少なくとも複数の部分に分割されており、分割された部分の間隙を通して、前記プローブが鳥瞰されるように、前記パッドと前記プローブが配置されていることを特徴とする請求項１７記載の近接場光ヘッド。
【請求項１９】前記プローブの先端部分に、前記プローブの構成物が露出した開口をさらに有し、前記開口と前記金属薄膜の表面とがほぼ同一平面になっていることを特徴とする請求項１７記載の近接場光ヘッド。
【請求項２０】情報記録媒体と相対運動をする光学的に透明なスライダと、前記スライダと前記情報記録媒体との間隔を制御する柱状の複数のパッドと、微小なスポットサイズの近接場光を発生する錐体形状のプローブとを有し、前記プローブが前記パッドの間に位置するように前記パッドと前記プローブが前記情報記録媒体と対向する前記スライダの面上に設けられていることを特徴とする近接場光ヘッド。
【請求項２１】情報記録媒体と相互運動をする光学的に透明な物質からなるスライダと、前記スライダと前記情報記録媒体との間隔を制御するパッドと、レーザ光を前記プローブに集光するレンズと、前記レンズにより集光されたレーザ光により近接場光を発生する錐体形状のプローブと、前記プローブをコーティングする金属薄膜と、前記情報記録媒体に対向する前記パッドの面に形成された摩耗防止薄膜と、を有し、前記パッドは４つに分割され、分割されたパットの中央に前記プローブが設けられていることを特徴とする近接場光ヘッド。
【発明の詳細な説明】
【０００１】

【発明の属する技術分野】本発明は、近接場光ヘッド、近接場光ヘッドの加工方法、および光情報処理装置に関し、特に超高記録密度でかつ転送速度を大きくするのに適した近接場光ヘッド、近接場光ヘッドの加工方法、および光情報処理装置に関する。

【0002】

【従来の技術】光ディスク装置の高密度化を達成する方法として近年、近接場光を応用した光記録が注目されている。例えば、アプライド・フィジクス・レターズ、61巻、2号の142頁から144頁（Ａｐｐｌｉｅｄ　Ｐｈｙｓｉｃｓ　Ｌｅｔｔｅｓ，Ｖｏｌ．６２，Ｎｏ．２，ｐｐ．１４２－１４４，１９９２）に記載されているように、光ファイバの先端をコーン状に加工し、その先端の数１０ｎｍの領域以外を金属の被膜で覆ったプローブを作製し、これをピエゾ素子を用いた精密アクチュエータに搭載して位置を制御して、直径６０ｎｍの記録マークをプラチナ／コバルトの多層膜上に記録再生した例が報告されている。この例の場合、プローブと記録媒体の距離制御には、原子間力を応用したシア・フォース方式が用いられ、記録密度は４５ギガビット／平方インチに達し、現状の約２０倍とすることができる。更に特開平３－１７１４３４号公報では、微小なピンホールにレンズで光を集光して近接場光を発生するとともに、前記微細ピンホールを先端に形成したカンチレバーと記録媒体の間に発生する原子間力を用いて前記微小ピンホールと記録媒体の間の距離を制御する方法、および媒体の上に光源、レンズ、微小ピンホールを収納したスライダを配置し、スライダをエア浮上させ、微小ピンホールと記録媒体の間の距離を制御する方法が考案されている。

【0003】

【発明が解決しようとする課題】光情報記録再生装置においては、情報の転送速度を大きくするため、記録媒体と情報を記録再生する光ヘッドの相対速度を大きくする必要がある。

【0004】しかし、プローブと記録媒体の距離制御に原子間力を応用したシア・フォース方式を応用した上記第一の従来例では、記録媒体と光ヘッド、すなわちファイバプローブとの距離をスキャニング・フォース顕微鏡を用いて、極めて精密に制御する必要があるため、情報を記録したディスクを高速に回転した場合、ディスクの偏心によって生じる高い周波数の基板とプローブの距離の変動を制御しきれず、転送速度をあげることができないという問題がある。

【0005】また、カンチレバーを応用した従来例では、カンチレバーの変位の検出方法としてキャパシタンスの変化やレーザ干渉計測が用いられており、近接場を発生させる照射光学系とは別の大がかりな光学系ないしキャパシタンス測定系を必要とし、装置が大型化、複雑化するという問題があった。また、アプライド・フィジクス・レターズ、６８巻、２５号の３５３１頁から３５３３頁（ＡｐｐｌｉｅｄＰｈｙｓｉｃｓ　Ｌｅｔｔｅｓ，Ｖｏｌ．６８，Ｎｏ．２５，ｐｐ．３５３１－３５３３，１９９６）の例では、カンチレバーの変位の検出方法として、カンチレバーの背面にレーザ光を照射し、カンチレバーの変位をリニアフォトダイオード上の光点の移動に変換して検知する光てこ方式が用いられているが、この場合も、近接場を発生させる照射光学系とは別の大がかりな光学系を必要とし、装置が大型化、複雑化するという問題があった。

【0006】また、媒体の上に光源、レンズ、微小ピンホールを収納したスライダを配置する従来例では、スライダ上に光源、レンズなどの多くの光学部品が搭載されている。このため、スライダの質量が増加し、記録媒体の回転に伴う上下振動への追従性能が劣化し、装置の構築が不可能になってしまう。さらに、前記特開平３－１７１４３４号公報には、具体的なピンホール、レーザ光源、レンズの搭載、形成方法が開示されていない。

【0007】本発明の目的は、近接場光発生用プローブを応用した超高密度光記録再生速度の、情報の転送速度を大きくするため、記録媒体と情報を記録再生する光ヘッドの相対速度を大きくすることが可能で、かつ記録媒体と光ヘッドの距離を検出するための付加的な設備が不用の、小型、軽量で簡略な構成の近接場光ヘッド、およびそれを用いた光記録再生装置を提供することにある。

【0008】

【課題を解決するための手段】上記課題を解決するために、以下の手段を採用した。

【0009】情報記録媒体と接触しつつ、もしくはほぼ一定の間隔を保って浮上しながら相対運動をする光学的に透明なスライダ上の、前記情報記録媒体と対向する面上に、前記スライダと前記情報記録媒体の接触ないし浮上の状態を制御するために設けられた円柱ないし角柱形状のパッドと、微小なスポットサイズの近接場光を発生させるプローブを近接して設け、さらに、前記パッドと前記プローブの、スライダの前記情報記録媒体と対向する面からの高さが略等しく、かつ前記プローブの前記情報記録媒体と対向する面からの高さが前記パッドの前記情報記録媒体と対向する面からの高さより小さくする。これにより、近接場ヘッドがスライダと一体形成され、従来の磁気ディスク装置で用いられているヘッドと同様の性能をもった、小型、軽量、簡略な構成の近接場光ヘッドが構成できる。また、スライダが小型、軽量となるため、記録媒体と情報を記録再生する光ヘッドの相対速度を大きくすることが可能となる。

【0010】さらに、前記近接場光ヘッドにおいて、前記パッドと前記プローブ上に光学的に不透明な薄膜、例えば金属薄膜を形成したり、さらにまた、前記プローブの先端部分において、前記プローブを構成する物体が露出している構造を有し、かつ前記プローブの露出している部分の表面と、前記金属薄膜の表面とが、実質的に同

一平面になる微小開口を作製することにより、微小なサイズの近接場光を発生させることができるようにする。

【００１１】さらに、前記近接場光ヘッドにおいて、前記パッド部を、前記プローブを囲むように配置し、さらにまた前記パッド部を少なくとも複数の部分に分割し、パッド側面より、分割された部分の間隙を通して、前記プローブを鳥瞰することが可能なように配置することにより、側面から粒子ビームを照射しエッチングすることで、プローブ形状を任意の錐体構造に加工したり、微小開口を作製することを可能とする。

【００１２】さらに、前記近接場光ヘッドと、前記近接場光ヘッドへの照明光を提供する光源と、光記録媒体と、前記近接場光ヘッドにより発生された近接場光の記録媒体による変調信号を検出する受光手段を用いて、超高密度の光記録再生装置を構成することができる。

【００１３】

【発明の実施の形態】以下、本発明の実施例を図面を用いて説明する。

【００１４】図１は本発明の一実施例であり、図１(a)は本発明の近接場光ヘッドの斜視図、図１（ｂ）は、図１(a)のＡＡにそった断面図である。

【００１５】図１(a)において、１は光学的に透明な物質からなるスライダである。本実施例では、波長７８０ｎｍの半導体レーザを光源とする場合について説明するので、スライダの材質は石英を選択したが、これに限定されるものではない。２から３はスライダと情報記録媒体１１の浮上の状態を制御するために設けられたパッドである。本実施例では、スライダ底面に３つのパッドが設けられている。そのうちの一つのパッド２は、４つに分割されており、その中央に近接場光発生用の四角錐形のプローブ４が設けられている。プローブ４には、図１（ｂ）に示されているように厚さ数１０ｎｍの金属薄膜５がコーティングされている。また、パッド２から３及びそれ以外のスライダの記録媒体に対向する面には、摩耗防止用の薄膜、例えばカーボン膜６がに約１０ｎｍ程度成膜されている。図１（ｂ）において、７は半導体レーザ光８を近接場光発生用プローブ４に集光するための対物レンズである。集光された半導体レーザ光８は、近接場光発生プローブ４の先端付近で微小なサイズの近接場光９に変換される。スライダは、記録媒体基板１０より数１０ｎｍ浮上して走行し、前記近接場光９により、基板１０上に形成された記録媒体１１への、情報１２の記録、再生が行われる。

【００１６】ここで、プローブ５の高さhは、必ずパッド２の高さｈより小さくされなければならない。図１（ｂ）で示したように、スライダは記録媒体基板１１より、わずか数１０ｎｍ浮上して走行する。パッド２の上面は、スライダと記録媒体基板１１との摺動面にあたる。このため、本ヘッドによる記録再生動作中に、スライダと記録媒体基板が接触する状況が発生した場合、パッド上面が記録媒体基板と接触する。このとき、プローブ４の高さhがパッド２の高さｈより大きいと、プローブ先端と記録媒体基板が接触し、プローブの摩耗を招く。これを防止するため、hはhより必ず小さくする必要がある。hをhより小さくするのみならず、hとｈの差も極めて小さくする必要がある。近接場光９の強度は、プローブ先端からの距離がプローブ先端のサイズ程度までは大きく変化しないが、プローブ先端からの距離がそれ以上に大きくなると、急激に減少することが知られている。本実施例の場合のプローブ先端のサイズは数１０から１００ｎｍであり、もし、プローブと媒体の距離がそれ以上大きくなった場合、近接場光１０の強度が記録媒体１１上で極めて小さくなってしまう。スライダは記録媒体表面から数１０ｎｍ浮上して走行するため、もし、プローブと媒体の距離をプローブ先端のサイズ、すなわち数１０から１００ｎｍ以下に保つためには、hとhをほぼ同じとし、スライダ走行時に、プローブ先端と記録媒体表面との距離も数１０ｎｍ程度に保つ必要がある。このためにはhとhの差をｎｍオーダーで制御しなければならない。この点が、本近接場光ヘッド作製の大きなポイントであり、作製方法については、後で詳述する。

【００１７】以上のような、近接場発生用プローブがスライダと一体形成された近接場光ヘッドを用いれば、従来の磁気ディスク装置で用いられているヘッドと同様の性能をもった、小型、軽量、簡略な構成の近接場光ヘッドが構成できる。かつ、スライダが小型、軽量となるため、記録媒体と情報を記録再生する光ヘッドの相対速度を大きくでき、情報の転送速度を向上することが可能となる。

【００１８】次に、本実施例で用いられている近接場光発生用プローブについて、図２から図６を用いて詳述する。

【００１９】図２(a)は、図１で用いられていた四角錐形状のプローブの拡大図、図２（ｂ）は三角柱状のプローブの拡大図である。また、図２（ｃ）は、図２(a)において四角錐の頂点を通り底面の２つの辺の中点B、Bを通る面（半導体レーザ光８の偏光方向と平行）、および図２（ｂ）において、三角柱の３つの辺の中点C、C、Cを通る面（半導体レーザ光８の偏光方向と平行）における断面図をあらわしている。

【００２０】図２(a)において、例えば、プローブ４が石英で形成されている場合、プローブ４上に形成されている金属薄膜５は、様々な種類のものが選択可能である。ただし、金属の種類と、図２（ｃ）で示された四角錐の頂角の半角θの間に、ある特定の関係がある場合、高い効率が得られる。半導体レーザ光８は、プローブ４の先端付近に集光されており、その波面はほぼ平面とみなせる。この場合、上記の角θと金属の種類を適当に組み合わせると、金属薄膜５内に表面プラズマ波１６が励振される。表面プラズマ波は数十ｎｍの薄い金属膜の中

でも伝播可能であり、表面プラズマ波に変換された半導体レーザ光は効率よくプローブ先端まで伝播し、高い効率で近接場光９を発生せしめることができる。例えば、プローブとして石英を用いると、金属としてアルミニウムを用いる場合θは約４２度、金を用いる場合θは約４４度、銀を用いる場合θは約４４度とする。図２（ｂ）では、プローブ１３の形状が三角柱であるため、プローブ先端付近に集められた光は断面CCCに平行な面内のみで集光される。ことため、図２(a)の場合とことなり、線状の近接場光１５が発生する。図２（ｂ）のような形状の場合も、その頂角の半角θと金属１４の種類の関係を、上記で説明したのと同様に設定すれば、高い効率が得られる。

【００２１】プローブ４、１３のサイズは特に限定されるものではないが、作製が容易であること、また、例えば、波長７８０ｎｍのレーザ光８を、開口数０．６の対物レンズ７で集光した場合、その集光スポットが約１．３μｍであることを考慮し、すべてのレーザ光が有効にプローブに集光されることを考えると、例えば、図２(a)の場合は四角錐底面の正方形の一辺を３から４μｍとするのが望ましい。また、図２（ｂ）の場合は、断面CCCに平行な２辺の長さは3から４μm程度とすることが望ましいが、断面CCCと垂直な２辺は、近接場光１５のスポットサイズによって様々な値を選択する。

【００２２】図3は、プローブ１７が円錐形状の場合の例である。この場合も円錐の頂角の半角θとプローブ上に成膜される金属１８の種類の関係が、上記のような特定の条件を満足すれば、高い効率で近接場光１０を発生することが可能である。

【００２３】図4は、近接場光発生用プローブの別の例である。図4(a)は、図２(a)で示された四角錐形状のプローブ５の先端部分が切除されたプローブ、図４（ｂ）は図２（ｂ）で示された三角柱形状１３の先端部分が切除されたプローブ、図４（ｃ）は、図4(a)において四角錐台の上面の四角形の二辺の中点D、Dおよび下面の四角形の二辺の中点D、Dの４点を通る面（半導体レーザ光８の偏光方向と平行）、および図４（ｂ）において、プローブ上面の上面の四角形の二辺の中点E、Eおよび下面の四角形の二辺の中点E、Eの４点を通る面（半導体レーザ光８の偏光方向と平行）における断面図をあらわしている。

【００２４】図4(a)において、プローブ１９は四角錐の先端が切除され、開口２１が形成されている。開口が形成されているプローブにおいては、プローブ表面に形成された光学的に不透明な薄膜２０、例えば金属膜が、対物レンズで集光された半導体レーザ光８の遮光膜として用いられる。この場合、記録再生に用いられる近接場光２２のサイズは、開口２１の大きさｄに金属膜への光のしみこみ深さを加えたものになる。後で詳述する加工法を用いると、最小で大きさ約２０ｎｍの開口が形成できる。遮光用の金属としては金、銀、白金、アルミニウム、クロムなどさまざまの金属が用いられる。これらの金属への波長７８０ｎｍの光のしみこみ深さは、典型的には１０から２０ｎｍであり、以上から、最小約４０ｎｍの近接場光スポットが形成可能である。図４（ｂ）では、プローブ２３の形状が三角柱であり、開口２５の形状も細長い長方形であるため、線状の近接場光２６が発生する。この場合、断面EEEE内の近接場光のサイズは、図４(a)の場合と同じであるが、断面EEEEと垂直方向のサイズは、長方形の長い方の辺の長さを選択することにより、自由に選択可能である。

【００２５】図４（ｃ）で示されたプローブの頂角φの値は、ほぼ３０から６０度程度とすると、高い透過効率のプローブが得られる。φが小さすぎると、プローブのテーパ部分の長さが大きくなる。一般に空間を伝播する光は、光の波長程度の大きさより小さい領域では伝播することができず、図４（ｃ）の例では、多くの光パワーが金属膜２０ないし２４に吸収されてしまう。このため、透過効率が小さくなる。一方φが大きくなりすぎると、ほとんどの光はプローブから反射されてしまう。したがって、φの値は、金属膜への光の漏れ出しを抑え、かつ反射を押さえるため、上記の適当な値の範囲にすることが望ましい。

【００２６】プローブ１９、２３のサイズは特に限定されるものではないが、作製が容易であること、また、例えば、波長７８０ｎｍのレーザ光８を、開口数０．６の対物レンズ７で集光した場合、その集光スポットが約１．３μｍであることを考慮し、すべてのレーザ光が有効にプローブに集光されることを考えると、例えば、図４(a)の場合は四角錐底面の正方形の一辺を３から４μｍとするのが望ましい。また、図４（ｂ）の場合は、断面EEEEに平行な２辺の長さは3から４μm程度とすることが望ましいが、断面EEEEと垂直な２辺は、上記で述べたように、近接場光２６のスポットサイズによって様々な値を選択する。

【００２７】図5は、プローブ２７が円錐形状であり、かつ頂点近傍が切除され、円形の開口２９が形成されているの場合の例である。この場合においても、近接場光３０のサイズは、開口２９の大きさに遮光膜２８への光のしみこみ深さを加えたものとなり、最小４０ｎm程度のサイズとすることが可能である。また、円錐の頂角の半角φの大きさは、前述した図４（ｃ）の場合と同様、３０から６０度程度とすると、高い透過効率を得ることができる。

【００２８】プローブ１９、２３、２７のような開口を有するプローブの場合、さらなる高い透過効率を得る研究が、光ファイバを化学エッチングして作製されたプローブに関して行われている。例えば、アプライド・フィジクス・レターズ、第６９巻、１９号の２６１２頁から２６１４頁(Applied physics Letters, Vol.69, No.19,

pp.2612-2614,1996)には、図６（ｂ）のごとく、プローブ３１の頂角を２段階に変え、根元の部分の頂角は小さく、先端の部分の頂角は大きくすることで、金属膜３２への光の漏れ出しを押え、かつプローブ３１からの反射を押さえ、透過効率の高いプローブを得ることができることが記載されている。本発明においても、後述する加工法を用いれば、容易に図６（ｂ）のような、透過効率の高いプローブを得ることができる。また、アプライド・フィジクス・レターズ、第７１巻、１３号の１７５６頁から１７５８頁(Applied physics Letters, Vol.71,No.13, pp.1756-1758,1997)には、図６（ｃ）のごとく、プローブ３５の形状を、プローブの中心線に対して非対称にし、表面プラズマ波を励振することによって、透過効率の高いプローブを得ることができることが記載されている。本発明においても、後述する加工法を用いれば、容易に図６（ｃ）のような、透過効率の高いプローブを得ることができる。

【００２９】図７は、接触型スライダを応用した本発明の第二の実施例である。図７(a)は本実施例の近接場光ヘッドの斜視図、図７（ｂ）は、図７(a)のFFにそった断面図である。

【００３０】図７(a)において、光学的に透明な物質からなるスライダ１上には、スライダ１と情報記録媒体１１の接触状態を制御するために設けられたパッド２が設けられている。図１の実施例では、スライダ底面に３つのパッドが設けられていたが、本実施例では、４つに分割されたパッド２のみが設けられている。パッド２の中央に近接場光発生用の四角錐形のプローブ４が設けられている。プローブ４には、図７（ｂ）に示されているように厚さ数１０ｎｍの金属薄膜５がコーティングされている。また、パッド２及びそれ以外のスライダの記録媒体に対向する面には、摩耗防止用の薄膜、例えばカーボン膜６がに約１０ｎｍ程度成膜されている。図７（ｂ）では、金属薄膜５と摩耗防止用の薄膜６として別々の材料を用いる例を示したが、耐摩耗性と、開口がない図２から３の項で述べたプローブの場合は表面プラズマ波の励振特性と、また開口を有する図４から６の項で述べたからプローブの場合は遮光特性の両方を満足できる材料、例えばクロム膜で、スライダ底面およびプローブ表面を覆うことも可能である。そうすれば、作製プロセスは一層容易になる。記録媒体表面には、摩耗防止用のカーボン膜３９が数ｎｍ成膜され、その上に高分子の潤滑剤がやはり数ｎｍ塗布されている。このカーボン膜と潤滑剤により、記録媒体１１の耐摩耗性が向上させられている。スライダ１は、記録媒体基板１０に接触しながら走行し、前記近接場光９により、基板１０上に形成された記録媒体１１への、情報１２の記録、再生が行われる。

【００３１】図８は、浮上型スライダを用いた本発明の第三の実施例である。図８(a)は本実施例の近接場光ヘッドの斜視図、図８（ｂ）は、図８(a)のＧＧにそった断面図である。

【００３２】図８(a)において、光学的に透明な物質からなるスライダ１上に、スライダと情報記録媒体１１の浮上の状態を制御するために設けられたパッド２、３が設けられている。本実施例では、スライダ底面に３つのパッドが設けられている。そのうちの一つのパッド２は、４つに分割されており、その中央に近接場光発生用の四角錐形のプローブ４が設けられている。本実施例においては、パッド２に設けられた４つの分割された小パッドの高さは、パッド２全体およびパッド３のスライダ底面からの高さより小さく設計されている。このようにすることにより、プローブ４のサイズの如何によらず、自由にスライダ底面からパッド上面までの高さを設計することができる。これにより、スライダの浮上量を、任意に設定することができる。また、パッド２に設けられた４つの分割された小パッドの高さは、実施例１と同じように、プローブ４の高さより僅かに高く設定する。スライダの浮上量を考慮することなく、プローブの形状、サイズに応じて自由に小パッドの高さが設定できるので、プローブ作製の自由度が大きくなる。

【００３３】上記実施例２および３では、プローブとして、図２(a)の形状のものを例にとって説明したが、図２から図６に示された、その他のすべてのプローブ形状に関しても、全く同様に実施例２および３のスライダ形状が適用できる。

【００３４】図９および図１０は、図１から図８に示された、近接場光ヘッドの作製工程を示した図である。

【００３５】まず、図９(a)のように、基板１上に、フォトレジスト４０を塗布、露光、現像して、パッド２、３、およびプローブ４を作製する部分のみをマスクとして残す。次に、図９（ｂ）のように、図９(a)で形成されたマスクパターンを、例えばアルゴンガスを用いたドライエッチングにより、基板１へ転写する。次に、図９（ｃ）のように、フォトレジスト４０を除去した後、スライダ底面およびパッド面を保護する保護膜６を、スパッタリング法などにより成膜する。次に、図９（ｄ）のように、集束イオンビーム（Focused Ion Beam:以下ＦＩＢと略称する）４１を用いたエッチングにより、プローブを所定の形に加工する。ＦＩＢ加工においては、例えばガリウムイオンを用いる場合、加速電圧を数十ｋＶ、ビーム電流を数１０ｐＡ程度とする。このときのＦＩＢ４１の集束位置におけるビームサイズは、数１０ｎｍであり、本発明のプローブを作製するのに十分の分解能である。　ＦＩＢ加工においては、加工すべきサンプルにイオンを照射しながら、放出する２次電子像をとり、得られた２次電子像を見ながら、自由にイオンを照射する位置を制御することができるので、多様な加工が、短時間で、かつ容易に行うことができる。上記プローブの加工では、まず基板の一側面から、パッド２の間

を通してイオンをプローブへ加工すべき中央の突起へ照射しながらエッチングを行う。これにより、中央の突起の形は直方体から、三角柱の形状に加工される。プローブ１３や２３を作製する場合は、これで加工が終わりである。プローブ４など、四角錐形状のプローブを作製する場合は、基板をプローブの中心軸に平行な軸のまわりで９０度回転させ、最初のエッチングの際のビームの方向と９０度をなす方向から、再びパッド２の間を通してイオンを照射しながら、エッチングを行い、最終的に錐体の形状に加工する。この際の全加工時間は基板の材質にもよるが、１０分程度である。このような、基板側面からのＦＩＢ加工を応用してプローブを作製することにより、パッドの高さとプローブの高さはおおむね等しく、かつプローブの高さがパッドの高さより僅かに小さく加工できる。ＦＩＢ加工の後、図9(e)のように、パッドおよびその他のスライダ底面をフォトレジスト４０で覆い、プローブのまわりのみを露出させ、プローブ上に金属膜5を成膜する。最後にリフトオフ法により、パッドおよびその他のスライダ底面上に成膜された金属を除去し、図9（ｆ）にような、近接場光ヘッドの作製を完了する。

【００３６】さらに、図4から６で示された開口を有するプローブを作製する場合は、図１０のように、完成した図9（ｆ）の状態のプローブに、再度側面からＦＩＢ４１を照射し、先端部分を切除する。開口の大きさの大小は、図１０に示した切りこみ量を制御することにより、自由に変えることができる。また、本方法によれば、図１０に示したごとく、切除されたプローブの先端は平坦となり、その高さはパッドの高さを越えることがない。したがって、プローブ先端が記録媒体１１と衝突して破損することがなく、信頼性を高めることができる。また、図6（ｂ）、（ｃ）に示された特殊な形状のプローブを作製する場合は、図9（ｄ）のＦＩＢ加工の際に、形状に応じてビーム位置を制御しながらエッチングを行う。このように、任意のプローブ形状を短い加工時間で形成できることが、ＦＩＢを用いた本加工法の大きな効果である。

【００３７】図１１は、本発明の近接場光ヘッドを応用した光記録再生装置の斜視図である。記録媒体基板１０および記録媒体膜１１からなるディスク４３は、ベース４２に固定されたスピンドルモータに連結された軸４４に取り付けられて回転する。この回転運動により図2から8のいずれかの近接場光ヘッドを搭載したスライダ1に対し、相対運動をする。スライダ1の位置決めを行うアクチュエータ４９も、ベース４２に固定されおり、その可動部４８には、アーム５０およびサスペンション５２が取り付けられている。可動部４８は、その中心軸の周りを回転し、サスペンション５２の先端に取り付けられたスライダを、ディスク４３の半径方向に移動させる。さらに、トラッキングピッチが小さいディスクを用いる場合には、アーム５０の先端部に、アクチュエータ４９より、さらに微細な位置決めを可能とするアクチュエータ５１を取り付ける。ベース４２に固定されたインターフェース４５には、コネクタ４６が接続され、コネクタ４６に接続されたケーブルを通して、本装置を駆動するための電源の供給、装置に対する記録再生命令、記録情報の入力、再生情報の出力を行う。近接場光ヘッドへのレーザ光の供給、および記録情報の検出、スライダのトラックからの位置ずれ情報の検出、および対物レンズとスライダの位置ずれの検出は、詳細は図１２で説明するが、ベースに固定された光学ヘッド５３を用いて行われる。スライダの直下には、ガルバノミラー、対物レンズ、および対物レンズを移動させるアクチュエータを搭載した可動部分５４が設置されている。図１１には陽には記載されていないが、可動部分５４は、可動部分全体を移動させるアクチュエータにより、ディスク４３の半径方向に、スライダ１に追従して移動させられる。

【００３８】次に、図１２を用いて、上記光ヘッド５３、および可動部分５４の動作について詳細に説明する。半導体レーザ５５によって発生されたレーザ光は、コリメートレンズ５６により平行ビームに変えられたのち、ビームスプリッタ５７を通過し、ガルバノミラー５８で方向を変えられる。ガルバノミラー５８で方向を変えられたレーザ光は、プローブ４上に対物レンズ7によって集光され、近接場光が発生させられ、ディスク４３上に形成された記録媒体への記録、再生が行われる。以下、プローブとして図2(a)に示されたプローブ４（およびそれを搭載するスライダ１）を例にとって説明するが、図2から図8に記載されたどのプローブ（およびそれを搭載するスライダ）を用いても、以下の内容は全く同じである。記録媒体の情報により強度を変調されたレーザ光は、対物レンズ7を通り、ガルバノミラー５８で再び方向を変えられ、ビームスプリッタ５７で反射し、検出系に導かれる。検出系では、読み出し信号の検出、および対物レンズ7によって集光されたレーザ光の焦点とプローブ４の光軸方向の位置ずれの検出と、光軸と垂直方向の位置ずれの検出が行われる。光軸と垂直方向のレーザ光焦点とプローブ４の位置ずれは、レンズ６０により集光され、ビームスプリッタ６１によ分割されたレーザ光を、一方向のみに集光するレンズ、例えばシリンドリカルレンズ６３により４分割光検出器６４上へ集光し、いわゆる非点収差法と呼ばれる焦点誤差検出方式を用いて行う。レーザ光の焦点とプローブ４の光軸と垂直方向のずれの検出は、４分割光検出器６２により以下のように行う。レーザ光の焦点が、プローブ４とディスク４３の半径方向に位置ずれすると、４分割光検出器の検出器Aと検出器Cの和信号と、検出器Ｂと検出器Dの和信号にアンバランスが生じる。したがってこれらの和信号の差を用いれば、位置ずれを検出できる。一方、レーザ光の焦点が、プローブ４とディスク４３の周方向にず

れると、4分割光検出器の検出器Aと検出器Bの和信号と、検出器Cと検出器Dの和信号にアンバランスが生じる。したがってこれらの和信号の差を用いれば、位置ずれを検出できる。これらの位置ずれ信号を用い、例えば、対物レンズの周りに取り付けられた2次元アクチュエータ59によりレーザ光の焦点とプローブ4の光軸方向の位置ずれおよびディスク43の周方向の位置ずれを、ガルバノミラー58に取り付けられたミラー58の傾きを移動させるアクチュエータにより、レーザ光の焦点とプローブ4のディスク43の半径方向の位置ずれを補正することにより、つねに対物レンズの焦点をプローブ4に合わせ、効率よく近接場光を発生せしめることができる。最後に、記録情報の再生は、例えば、ディスク上に形成された記録媒体として、いわゆる相変化型の記録媒体や再生専用の凹凸記録媒体を用いる場合は、2つの4分割検出器62、64のすべての検出器の和信号の強度を用いて行う。

【0039】次に、本発明における位置決め、サーボ技術について図13を用いて説明する。図13において、65から71は、ディスク上に設けられた多くの情報トラックのうちの7本を示している。72は、トラック番号を識別するアドレスマーク群であり、トラック毎に異なっており、このマークによってプローブ4がどのトラック上に位置するかを検知する。各トラックには、ウォブルマーク73とクロックマーク74が設けられている。情報の記録再生の際、プローブ4は図13において、図の下から上に移動する。プローブ4は、クロックマーク74を通りクロックが作成された後、ウォブルマーク73上を通過する。もしプローブの位置がトラック中心からずれていた場合、連続した2つのウォブルマークからの信号にアンバランスが生じ、これらの信号の差をとってトラッキング誤差信号とする。この誤差信号に応じてアクチュエータ49（もし取り付けられていればアクチュエータ51も）を駆動し、プローブ4をトラック中心に位置合わせする。対物レンズ7は、前述のように常にプローブ4上にレーザ光の焦点が位置するように動作するので、レーザ光の焦点も上記のサーボ動作に追従してサーボされる。プローブ4は、ウォブルマーク73の上を通過した後、アドレスマーク72上を通過し、情報を記録する記録部75上へ入り、情報の記録再生が行われる。

【0040】次に、プローブ4を目的のトラックまで移動させるシーク動作について述べる。シーク動作においては、図11のシステムコントローラ47から、外部の制御装置から指定された情報を記録、再生すべき位置と、4分割光検出器62、64によって検出された実際のプローブ4の位置を比較する。この比較結果を基に、位置決めアクチュエータ49（もし取り付けられていればアクチュエータ51も）を駆動し、プローブ4をディスク上の所定のトラックに位置決めする。このとき、対物レンズ7は、レーザ光の焦点位置とプローブ4の位置が、光軸方向、および光軸と垂直な平面内でかつディスクの周方向にずれないよう、アクチュエータ59でサーボされながら、かつ、図12には陽には記載されていないが、可動部54全体をディスクの半径方向に移動させるアクチュエータにより、プローブを搭載したスライダ1に追従して移動させられる。スライダ1および可動部54は極めて軽量であり、このためシークに要する時間を、通常の磁気ディスク装置並みに短くすることができる。

【0041】図14は、本発明の他の実施例を示す図である。図14(a)は、対物レンズ76が、スライダ1上に集積されたれた例である。レンズ76としては、通常の曲面形状のレンズの他、フレネルレンズなどの回折格子を応用したレンズを用いることができる。図14（b）は、対物レンズ78の他、半導体レーザ77、光検出器79がスライダ1上に搭載された例である。この場合、対物レンズ78としてフレネルレンズなど回折格子を用いた平面レンズを、半導体レーザとしては面発光レーザを用いると、装置が非常に小型になる。図14（b）の例では、レーザ光の焦点とプローブ4の相互の位置合わせは全く不要となり、図11、図12に記載された光ヘッド部53、54は不要となる。このような構成にすれば、装置構成は、現状の磁気ディスク装置と全く同様の構成となり、極めて薄型、小型の光記録再生装置を構成できる。

【0042】図15は、本は発明のさらに他の実施例を示す図である。これまでの例では、情報の検出を、プローブからの反射光を用いて行う例を示したが、図15は、ディスクからの透過光を用いる例を示している。情報12からの再生信号は、対物レンズ80により検出器82上に集光される。光記録媒体11として光磁気記録媒体を用いる場合は、さらに検出器82の前に、透過光の偏光方向を制御する素子81を挿入し、検出を行う。

【0043】以上においては、スライダ1の底面に3つのパッドが設けられ、そのうちの一つのパッド2は、4つに分割されており、その中央に近接場光発生用の四角錐形のプローブ4が設けられている例を説明してきたが。図16のように、さらに簡単な構成とすることも可能である。図16(a)において、スライダ1の底面に3つのパッド2が設けられている。そのうちのひとつのパッドの内側に近接して、近接場光発生用の四角錐形のプローブ4が設けられている。プローブ4としては、図2から図6に示されたいずれの形状のプローブを用いることが可能である。また、図16では、図1に対応する浮上型のスライダの例を示したが、図7の接触型スライダを用いることも可能である。図16(b)においては、図8のごとく、近接場光発生用のプローブ4が近接して設置されたパッド83と近接場光発生用のプローブ4がひとつの共通の土台上84に形成され、パッド83の高さ

は、ほかのパッドパッド3のスライダ底面からの高さより小さく設計されている例である。これらの例では、スライダの構造が簡単であり、その作製がより容易になるという利点がある。

【0044】

【発明の効果】以上のように本発明によれば、情報の転送速度を大きくするため、記録媒体と情報を記録再生する光ヘッドの相対速度を大きくすることが可能で、かつ記録媒体と光ヘッドの距離を検出するための付加的な設備が不用の、小型、軽量で簡略な構成の、近接場光ヘッドおよびそれを用いた光記録再生装置を提供することが可能となる。

【図面の簡単な説明】

【図1】本発明の第1の近接場光ヘッドの実施例を示す図であり、(a)は斜視図、（ｂ）は断面図。

【図2】近接場光ヘッドで用いられているプローブの一例を表す図であり、(a)、（ｂ）は斜視図、（ｃ）は断面図。

【図3】近接場光ヘッドで用いられているプローブの他の一例を表す斜視図。

【図4】近接場光ヘッドで用いられているプローブの他の一例を表す図であり、(a)、（ｂ）は斜視図、（ｃ）は断面図。

【図5】近接場光ヘッドで用いられているプローブの他の一例を表す斜視図。

【図6】本発明で用いる半導体レーザプローブを表す断面図。

【図7】接触型スライダを用いた本発明の第2の実施例を示す図であり、(a)は斜視図、（ｂ）は断面図。

【図8】本発明の第3の実施例を示す図であり、(a)は斜視図、（ｂ）は断面図。

【図9】図1から図8までに示された種々の近接場光ヘッドの作製工程を示す図。

【図10】図5、6の近接場光ヘッドの作製工程を示す図。

【図11】本発明の近接場光ヘッドを応用した光記録再生装置の斜視図。

【図12】図11で用いられる光ヘッド部の詳細を示す図。

【図13】本発明の光記録再生装置におけるサーボ動作を説明する図。

【図14】本発明の近接場光ヘッドの他の実施例を示す図。

【図15】本発明の光記録再生装置の他の例を示す図。

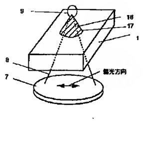
【図16】本発明のスライダーの第4の実施例を示す図。

【符号の説明】

1…スライダ、2…パッド、3…パッド、4…プローブ、5…金属薄膜、6…摩耗防止用の薄膜、7…対物レンズ、8…半導体レーザ光、9…近接場光、10…基板、11…記録媒体、12…記録情報、13…プローブ、14…金属薄膜、15…近接場光、16…表面プラズマ波、17…プローブ、18…金属薄膜、19…プローブ、20…遮光膜、21…開口、22…近接場光、23…プローブ、24…遮光膜、25…開口、26…近接場光、27…プローブ、28…遮光膜、29…開口、30…近接場光、31…プローブ、32…遮光膜、33…開口、34…近接場光、35…プローブ、36…遮光膜、37…開口、38…近接場光、39…摩耗防止用薄膜、40…フォトレジスト、41…ＦＩＢ、42…ベース、43…ディスク、44…軸、45…インターフェース、46…コネクタ、47…システムコントローラ、48…可動部、49…アクチュエータ、50…アーム、51…アクチュエータ、52…サスペンション、53…光学ヘッド、54…光学ヘッド可動部、55…半導体レーザ、56…コリメートレンズ、57…ビームスプリッタ、58…ガルバノミラー、59…2次元アクチュエータ、60…レンズ、61…ビームスプリッタ、62…4分割光検出器、63…シリンドリカルレンズ、64…4分割光検出器、65、66、67、68、69、70、71…情報トラック、72…アドレスマーク、73…ウォブルマーク、74…クロックマーク、75…情報記録部、76…対物レンズ、77…半導体レーザ、78…対物レンズ、79…光検出器、80…対物レンズ、81…偏光制御素子、82…光検出器、83…パッド、84…土台。

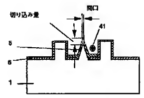
【図3】

図3



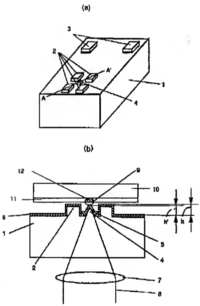
【図10】

図10



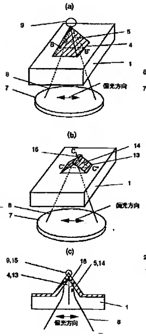
【図1】

図1



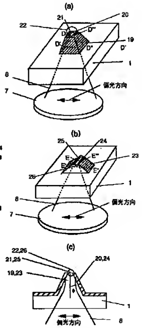
【図2】

図2



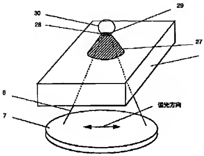
【図4】

図4



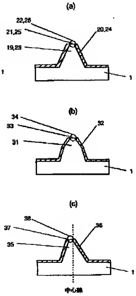
【図5】

図5



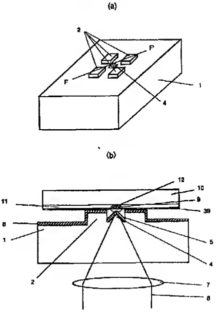
【図6】

図6



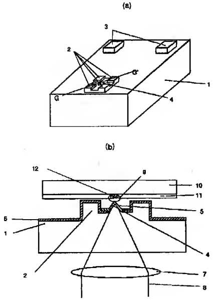
【図7】

図7



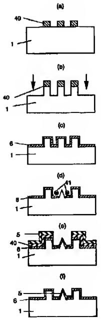
【図8】

図8



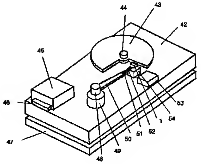
【図9】

図9



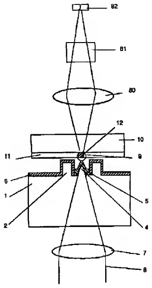
【図11】

図11



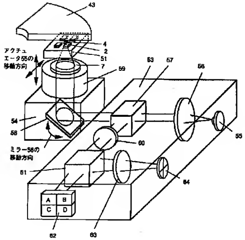
【図15】

図15



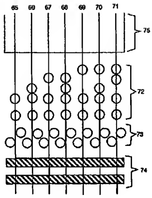
【図12】

図12



【図13】

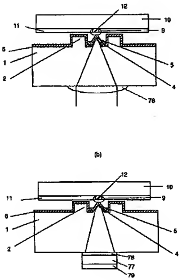
図13



【図14】

図14

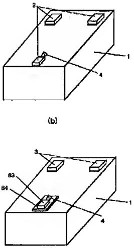
(a)



【図16】

図16

(a)



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CLAIMS

[Claim(s)]
[Claim 1]An optically transparent slider which carries out relative motion contacting an information recording medium while maintaining an almost fixed interval, A pillar-shaped pad which is provided on a field of said information recording medium and said slider which counters, and controls contact of said slider and said information recording medium, or a state of surfacing, A near field light head, wherein it has a probe of cone shape which generates near field light of a minute spot size, and said pad and said probe approach and are formed.
[Claim 2]The near field light head according to claim 1 to which height of said probe is characterized by being lower than height of said pad.
[Claim 3]The near field light head according to claim 2, wherein an opaque thin film is optically formed on said probe.
[Claim 4]The near field light head according to claim 3, wherein said thing [that an opaque thin film is metal optically].
[Claim 5]The near field light head according to claim 4 arranging so that said pad may surround said probe.
[Claim 6]The near field light head according to claim 5 characterized by arranging said pad and said probe so that it may let a gap of a portion which said pad is divided into two or more portions at least, and was divided pass and may look down at said probe.
[Claim 7]The near field light head according to claim 5, wherein it has further the opening which a structure of said probe exposed in a tip end part of said probe and said opening and the surface of said metal thin film have become it at the same flat surface mostly.
[Claim 8]A processing method of a near field light head processing a probe into cone structure by etching by exposure of a particle beam in a processing method of a near field light head which processes the probe according to claim 4.
[Claim 9]A processing method of a near field light head forming an opening by irradiating with and etching a particle beam into said thin film in a processing method of a near field light head which processes the probe according to claim 4.
[Claim 10]Optical recording playback equipment comprising:
The near field light head according to claim 4.
A light source which provides irradiation light to said near field light head.
An optical recording medium.
A light-receiving means to detect a modulating signal by a recording medium of near field light generated by said near field light head.

[Claim 11]A means to condense irradiation light to said probe in the optical recording playback equipment according to claim 10, A means to detect a gap of a focal position and a probe position of illumination light condensed by said condensing means, and optical recording playback equipment having a movable mechanism which amends a relative position of said condensing means and said

probe.
[Claim 12]In the optical recording playback equipment according to claim 11, a movable mechanism which amends a relative position of said condensing means and said probe, and said condensing means, Optical recording playback equipment carrying on a movable mechanism which is separated from other components which constitute a light information recording and reproducing device, and makes said condensing means access a position of a recording medium.
[Claim 13]A pad which carries out an information recording medium and relative motion and which controls an interval of a transparent slider, and said information recording medium and said slider optically, A near field light head, wherein it has a probe of cone shape which generates near field light and said pad and said probe are approached and formed on a field of said information recording medium and said slider which counters.
[Claim 14]The near field light head according to claim 13 to which height of said probe is characterized by being lower than height of said pad.
[Claim 15]The near field light head according to claim 14, wherein an opaque thin film is optically formed on said probe.
[Claim 16]The near field light head according to claim 15, wherein said thing [that an opaque thin film is metal optically].
[Claim 17]The near field light head according to claim 16 arranging so that said pad may surround said probe.
[Claim 18]The near field light head according to claim 17 characterized by arranging said pad and said probe so that it may let a gap of a portion which said pad is divided into two or more portions at least, and was divided pass and may look down at said probe.
[Claim 19]The near field light head according to claim 17, wherein it has further the opening which a structure of said probe exposed in a tip end part of said probe and said opening and the surface of said metal thin film have become it at the same flat surface mostly.
[Claim 20]A near field light head which is provided with the following and characterized by forming said pad and said probe on a field of said information recording medium and said slider which counters so that said probe may be located between said pads.
An optically transparent slider which carries out an information recording medium and relative motion.
Two or more pillar-shaped pads which control an interval of said slider and said information recording medium.
A probe of cone shape which generates near field light of a minute spot size.

[Claim 21]A near field light head comprising:
A slider which considers mutual movement as an information recording medium and which consists of a transparent substance optically.
A pad which controls an interval of said slider and said information recording medium.
A lens which condenses a laser beam to said probe.
A probe of cone shape which generates near field light by a laser beam condensed with said lens, It is said probe to a center of putt which it has a metal thin film which coats said probe, and the wear prevention thin film formed in a field of said pad which counters said information recording medium, and said pad was divided into four, and was divided.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]Especially this invention relates to the processing method of a near field light head and a near field light head which is super-high recording density and was suitable for enlarging a transfer rate, and an optical information processing device about the processing method of a near field light head and a near field light head, and an optical information processing device.
[0002]
[Description of the Prior Art]The optical recording adapting near field light attracts attention as a method of attaining the densification of an optical disk unit in recent years. For example, the tip of an optical fiber is processed into cone shape as indicated from 142 pages of applied physics Letters, 61 volumes, and No. 2 to 144 pages (Applied Physics Lettes, Vol.62, No.2, pp.142-144-1992), The probe which covered except several 10-nm field at the tip with the metaled tunic is produced, this is carried in the precision actuator using a piezo-electric element, a position is controlled, and the example which carried out record reproduction of the recording mark 60 nm in diameter on the multilayer film of platina/cobalt is reported. In the case of this example, the Xia force method which applied atomic force to the distance control of a probe and a recording medium is used, and storage density reaches [square inch] in 45 gigabits /, and can be made into about 20 times of the actual condition. While condensing light with a lens at a minute pinhole in JP,3-171434,A and generating near field light, How to control the distance between said minute pinholes and a recording medium using the atomic force which generates said detailed pinhole between the cantilever and recording medium which were formed at the tip, And a light source, a lens, and the slider that stored minute pinholes are arranged on a medium, exhaust air surfacing of the slider is carried out, and the method of controlling the distance between minute pinholes and a recording medium is devised.
[0003]
[Problem(s) to be Solved by the Invention]In a light information recording and reproducing device, in order to enlarge the transfer rate of information, it is necessary to enlarge relative velocity of the optical head which carries out record reproduction of a recording medium and the information.
[0004]However, in the first conventional example adapting the Xia force method which applied atomic force to the distance control of a probe and a recording medium of the above. Since it is necessary using a scanning force microscope to control very precisely the distance of a recording medium and an optical head, i.e., a fiber probe, When the disk which recorded information is rotated at high speed, change of the substrate of high frequency and the distance of a probe produced with the eccentricity of a disk cannot be controlled, and there is a problem that a transfer rate cannot be gathered.
[0005]In the conventional example adapting a cantilever, change of capacitance and laser interference measurement are used as a detecting method of displacement of a cantilever, The large-scale optical system other than the irradiation optical system which generates approaching space thru/or the capacitance system of measurement were needed, and there was a problem that a device was enlarged and complicated. In a 3531 to 3533 pages [of applied physics Letters, 68 volumes, and No. 25]

(AppliedPhysics Lettes, Vol.68, No.25, pp.3531-3533-1996) example. Although the back of a cantilever is irradiated with a laser beam and the optical-lever method which changes displacement of a cantilever into movement of the light spot on a linear photo-diode, and detects it is used as a detecting method of displacement of a cantilever, The large-scale optical system other than the irradiation optical system which generates approaching space also in this case was needed, and there was a problem that a device was enlarged and complicated.

[0006]In the conventional example which arranges on a medium a light source, a lens, and the slider that stored minute pinholes, many optics, such as a light source and a lens, are carried on the slider. For this reason, the mass of a slider will increase, the flattery performance to the vertical vibration accompanying rotation of a recording medium will deteriorate, and construction of a device will become impossible. Loading of a concrete pinhole, a laser light source, and a lens and a formation method are not indicated by said JP,3-171434,A.

[0007]The purpose of this invention can enlarge relative velocity of the optical head which carries out record reproduction of a recording medium and the information, in order to enlarge the transfer rate of information of the super-high-density optical recording reproduction speed adapting the probe for near-field-light generating. And providing unnecessary small size, the near field light head of lightweight and simple composition, and the optical recording playback equipment using it has the additional equipment for detecting the distance of a recording medium and an optical head.

[0008]

[Means for Solving the Problem]The following means were adopted in order to solve an aforementioned problem.

[0009]An optically transparent slider top which carries out relative motion contacting an information recording medium while maintaining an almost fixed interval and rising to surface, A pillar provided on said information recording medium and a field which counters in order to control contact of said slider and said information recording medium thru/or a state of surfacing thru/or a square pillar-shaped pad, Approach and a probe which generates near field light of a minute spot size is formed, Height from said pad, said information recording medium of a slider of said probe, and a field that counters spreads abbreviation etc., and height from said information recording medium of said probe and a field which counters makes it smaller than height from said information recording medium of said pad, and a field which counters. Thereby, an approaching space head is a slider and really formed and a head used with the conventional magnetic disk drive, and small size and a near field light head of lightweight and simple composition with the same performance can be constituted. Small size and since it becomes lightweight, a slider becomes possible [enlarging relative velocity of an optical head which carries out record reproduction of a recording medium and the information].

[0010]In [further again] a tip end part of said probe in forming an opaque thin film, for example, a metal thin film, optically on said pad and said probe in said near field light head ****, When the surface of a portion which had the structure which an object which constitutes said probe has exposed, and has exposed said probe, and the surface of said metal thin film produce a minute opening which becomes the same flat surface substantially, it enables it to generate near field light of minute size.

[0011]It lets a gap of a portion which has arranged said pad section in said near field light head so that said probe may be surrounded, divided said pad section into two or more portions at least further again, and was divided from the pad side pass, By arranging so that looking down at said probe may be possible, it makes it possible to process probe shape into arbitrary cone structures, or to produce a minute opening by irradiating with and etching a particle beam from the side.

[0012]Optical recording playback equipment of super high density can be constituted using a light-receiving means to detect a modulating signal by said near field light head, light source which provides illumination light to said near field light head, optical recording medium, and a recording medium of near field light generated by said near field light head.

[0013]

[Embodiment of the Invention]Hereafter, the example of this invention is described using a drawing.

[0014]Drawing 1 is one example of this invention, and it is the sectional view where drawing 1 (a) met

the perspective view of the near field light head of this invention, and drawing 1 (b) met AA of drawing 1 (a).

[0015]In drawing 1 (a), 1 is a slider which consists of a transparent substance optically. In this example, since the case where a semiconductor laser with a wavelength of 780 nm was used as a light source was explained, the construction material of the slider chose quartz, but it is not limited to this. 2 to 3 is the pad provided in order to control the state of surfacing of a slider and the information recording medium 11. In this example, three pads are provided in the slider bottom. The one pad 2 of them is divided into four, and the probe 4 of the pyramid type for near-field-light generating is formed in the center. The probe 4 is coated with the with a number of thickness of 10 nm metal thin film 5 as shown in drawing 1 (b). the thin film 6 for the prevention from wear, for example, a carbon film, resembles the field which counters the recording medium of the pads 2-3 and the other slider, and membranes are formed by about 10 nm in it. In drawing 1 (b), 7 is an object lens for condensing the semiconductor laser beam 8 to the probe 4 for near-field-light generating. The condensed semiconductor laser beam 8 is changed into the near field light 9 of minute size near the tip of the near-field-light generating probe 4. From the recording-medium board 10, as for a slider, 10 nm of numbers surface, it runs, and record of the information 12 to the recording medium 11 formed on the substrate 10 of said near field light 9 and reproduction are performed.

[0016]Here, height h of the probe 5 must be made smaller than height h of the pad 2. As drawing 1 (b) showed, from the recording-medium board 11, only several 10 nm of sliders surface, and run. The upper surface of the pad 2 hits the sliding surface of a slider and the recording-medium board 11. For this reason, when the situation where a slider and a recording-medium board contact during the record reproduction operation by this head occurs, the pad upper surface contacts a recording-medium board. If height h of the probe 4 is larger than height h of the pad 2 at this time, a recording-medium board will contact the end of the probe, and wear of a probe will be caused. In order to prevent this, it is necessary to make h certainly smaller than h. It is necessary it not only to to make h smaller than h, but to make the difference of h and h very small. It is known that the intensity of the near field light 9 will decrease rapidly if the distance from the end of the probe becomes larger than it although the distance from the end of the probe does not change a lot to the size grade of the end of the probe. The size of the end of the probe in the case of this example is several 10 to 100 nm, and when the distance of a probe and a medium becomes large more, the intensity of the near field light 10 will become very small on the recording medium 11. In order for several 10 nm of sliders to surface and to run from a recording medium surface, and to keep the distance of a probe and a medium at 100 from the size of the end of the probe, i.e., several 10, nm or less, It is necessary to make h and h almost the same and to also keep the distance of the end of the probe and a recording medium surface at about several 10 nm at the time of a slider run. For the purpose, the difference of h and h must be controlled by nm order. This point is a big point of this near field light head production, and a manufacturing method is explained in full detail later.

[0017]If the near field light head in which the above probes for approaching space generating were a slider and really formed is used, the head used with the conventional magnetic disk drive, and small size and the near field light head of lightweight and simple composition with the same performance can be constituted. And small size and since it becomes lightweight, a slider can enlarge relative velocity of the optical head which carries out record reproduction of a recording medium and the information, and it becomes possible to improve the transfer rate of information.

[0018]Next, the probe for near-field-light generating used by this example is explained in full detail using drawing 6 from drawing 2.

[0019]The enlarged drawing of the pyramid-shaped probe with which drawing 2 (a) was used by drawing 1, and drawing 2 (b) are the enlarged drawings of the probe of trianglepole shape. In the field (parallel to the polarization direction of the semiconductor laser beam 8) where drawing 2 (c) passes along the middle points B and B of two neighborhoods at the bottom through the vertex of a pyramid in drawing 2 (a), and drawing 2 (b), The sectional view in the field (parallel to the polarization direction of the semiconductor laser beam 8) passing through the middle point C, C, and C of three neighborhoods of

a triangular prism is expressed.
[0020]When the probe 4 is formed with quartz, it is [in / drawing 2 (a) / thin film / 5 / which is formed on the probe 4 / metal] selectable in various kinds of things. However, high efficiency is obtained when a certain specific relation between the half width theta of a metaled kind and the vertical angle of the pyramid shown by drawing 2 (c) is. It is condensed near the tip of the probe 4 and the semiconductor laser beam 8 can consider mostly that the wave front is a flat surface. In this case, if the above-mentioned angle theta and a metaled kind are combined suitably, the surface plasma wave 16 will be excited in the metal thin film 5. A surface plasma wave can be spread also in a tens of nm thin metal membrane, and the semiconductor laser beam changed into the surface plasma wave can be efficiently spread to the end of the probe, and can make the near field light 9 generate at high efficiency. For example, if quartz is used as a probe, when using aluminum as metal, theta uses gold about 42 degrees and theta uses silver about 44 degrees, theta may be about 44 degrees. In drawing 2 (b), since the shape of the probe 13 is a triangular prism, the light collected near the end of the probe is condensed only in a field parallel to the section CCC. things -- a sake -- drawing 2 -- (-- the linear near field light 15 occurs in the case of a), and a thing. High efficiency will be obtained if the half width theta of the vertical angle and the relation of the kind of metal 14 are set up the same with having explained above also in shape like drawing 2 (b).
[0021]Production is easy although the size in particular of the probes 4 and 13 is not limited, If it, for example, considers that all the laser beams are effectively condensed by the probe in consideration of the condensing spot being about 1.3 micrometers when the laser beam 8 with a wavelength of 780 nm is condensed with the object lens 7 of the numerical aperture 0.6, For example, in the case of drawing 2 (a), it is desirable for one side of the square at the bottom of a pyramid to be 3 to 4 micrometers. Although it is desirable to be referred to as about 3 to 4 micrometers as for a length of two sides parallel to the section CCC in the case of drawing 2 (b), two sides vertical to the section CCC choose various values with the spot size of the near field light 15.
[0022]Drawing 3 is an example in case the probe 17 is conical shape. If the half width theta of a conic vertical angle and the relation of the kind of metal 18 formed on a probe satisfy the above specific conditions also in this case, it is possible to generate the near field light 10 at high efficiency.
[0023]Drawing 4 is another example of the probe for near-field-light generating. The probe with which the tip end part of the pyramid-shaped probe 5 with which drawing 4 (a) was shown by drawing 2 (a) was excised, The probe and drawing 4 (c) from which the tip end part of the triangular prism shape 13 shown by drawing 2 (b) was excised drawing 4 (b), In the field (parallel to the polarization direction of the semiconductor laser beam 8) which passes along four points of the middle points D and D of two sides of the quadrangle of the upper surface of a truncated four-sided pyramid, and the middle points D and D of two sides of a quadrangle at the bottom in drawing 4 (a), and drawing 4 (b), The sectional view in the field (parallel to the polarization direction of the semiconductor laser beam 8) which passes along four points of the middle points E and E of two sides of the quadrangle of the upper surface on the upper surface of a probe and the middle points E and E of two sides of a quadrangle at the bottom is expressed.

[0024]In drawing 4 (a), as for the probe 19, the tip of a pyramid is excised and the opening 21 is formed. In the probe with which the opening is formed, it is used as a light-shielding film of the semiconductor laser beam 8 by which the opaque thin film 20, for example, a metal membrane, was optically condensed with the object lens formed in the probe surface. In this case, the size of the near field light 22 used for record reproduction becomes what the light to the metal membrane sank into size d of the opening 21, and applied the depth. If the processing method explained in full detail later is used, an opening with a size of about 20 nm can be formed at the minimum. As metal for protection from light, various metal, such as gold, silver, platinum, aluminum, and chromium, is used. Light with a wavelength [to these metal] of 780 nm sinks in, and typically, the depth is 10 to 20 nm, as mentioned above can form a minimum of about 40-nm near field light spot. In drawing 4 (b), the shape of the probe 23 is a triangular prism, and since it is a rectangle also with long and slender shape of the opening 25, the linear near field light 26 occurs. In this case, although the size of the near field light in the section

EEEE is the same as the case of drawing 4 (a), it is freely selectable by choosing the length of the neighborhood with a longer rectangle in the size of the section EEEE and a perpendicular direction.
[0025]If the value of the vertical angle phi of the probe shown by drawing 4 (c) is made into about about 30 to 60 degrees, the probe of high transmission efficiency will be obtained. If phi is too small, the length of the taper part of a probe will become large. The light which generally spreads space will not be able to be spread in a field smaller than the size about the wavelength of light, but much light power will be absorbed by the metal membranes 20 thru/or 24 in the example of drawing 4 (c). For this reason, transmission efficiency becomes small. On the other hand, if phi becomes large too much, almost all lights will be reflected from a probe. Therefore, in order that the value of phi may press down leakage **** of the light to a metal membrane and may press down reflection, it is desirable to use the range of the suitable above-mentioned value.
[0026]Production is easy although the size in particular of the probes 19 and 23 is not limited, If it, for example, considers that all the laser beams are effectively condensed by the probe in consideration of the condensing spot being about 1.3 micrometers when the laser beam 8 with a wavelength of 780 nm is condensed with the object lens 7 of the numerical aperture 0.6, For example, in the case of drawing 4 (a), it is desirable for one side of the square at the bottom of a pyramid to be 3 to 4 micrometers. Although it is desirable to be referred to as about 3 to 4 micrometers as for a length of two sides parallel to the section EEEE in the case of drawing 4 (b), two sides vertical to the section EEEE choose various values with the spot size of the near field light 26, as stated above.
[0027]The probe 27 is conical shape and drawing 5 is an example of a forming [the neighborhood of the peak is excised and / the circular opening 29] case. Also in this case, the size of the near field light 30 can become what the light to the light-shielding film 28 sank into the size of the opening 29, and applied the depth to it, and can choose size of about a minimum of 40 nm. Like the case of drawing 4 (c) mentioned above, if the size of the half width phi of a conic vertical angle is made into about 30 to 60 degrees, it can acquire high transmission efficiency.
[0028]In the case of the probe which has an opening like the probes 19, 23, and 27, research which acquires the further high transmission efficiency is done about the probe produced by carrying out chemical etching of the optical fiber. For example, to 2614 pages (Applied physics Letters, Vol.69, No.19, pp.2612-2614-1996), from 2612 pages of applied physics Letters, the 69th volume, and No. 19 like drawing 6 (b), The vertical angle of the probe 31 is changed into two steps, the vertical angle of the portion of a root is small, and leakage **** of the light to the metal membrane 32 is pressed down by enlarging the vertical angle of the portion at a tip, and the reflection from the probe 31 is pressed down, and it is indicated that a probe with high transmission efficiency can be obtained. Also in this invention, if the processing method mentioned later is used, a probe with high transmission efficiency like drawing 6 (b) can be obtained easily. To 1758 pages (Applied physics Letters, Vol.71, No.13, pp.1756-1758-1997), from 1756 pages of applied physics Letters, the 71st volume, and No. 13, like drawing 6 (c), It is indicated by by making shape of the probe 35 unsymmetrical to the center line of a probe, and exciting a surface plasma wave that a probe with high transmission efficiency can be obtained. Also in this invention, if the processing method mentioned later is used, a probe with high transmission efficiency like drawing 6 (c) can be obtained easily.
[0029]Drawing 7 is the second example of this invention adapting a contact type slider. It is the sectional view where drawing 7 (a) met the perspective view of the near field light head of this example, and drawing 7 (b) met FF of drawing 7 (a).
[0030]In drawing 7 (a), the pad 2 provided in order to control the contact state of the slider 1 and the information recording medium 11 is formed on the slider 1 which consists of a transparent substance optically. In the example of drawing 1, although three pads were provided in the slider bottom, only the pad 2 divided into four is formed at this example. The probe 4 of the pyramid type for near-field-light generating is formed in the center of the pad 2. The probe 4 is coated with the with a number of thickness of 10 nm metal thin film 5 as shown in drawing 7 (b). the thin film 6 for the prevention from wear, for example, a carbon film, resembles the field which counters the recording medium of the pad 2 and the other slider, and membranes are formed by about 10 nm in it. Although drawing 7 (b) showed

the example using a material separate as the metal thin film 5 and the thin film 6 for the prevention from wear, Since the paragraph of 6 described the excitation characteristic of the surface plasma wave from drawing 4 which has an opening again in the case of the probe described as abrasion resistance by the paragraph of 3 from drawing 2 without an opening, in the case of a probe, it is the material with which it can be satisfied of both protection-from-light characteristics, for example, a chromium film, It is also possible to cover the slider bottom and a probe surface. Then, production processes become still easier. In a recording medium surface, the several nanometers carbon film 39 for the prevention from wear is formed, and several nanometers lubricant of polymers is too applied on it. The abrasion resistance of the recording medium 11 is raised by this carbon film and lubricant. The slider 1 runs contacting the recording-medium board 10, and record of the information 12 to the recording medium 11 formed on the substrate 10 of said near field light 9 and reproduction are performed.

[0031]Drawing 8 is the third example of this invention which used the risen [to surface] type slider. It is the sectional view where drawing 8 (a) met the perspective view of the near field light head of this example, and drawing 8 (b) met GG of drawing 8 (a).

[0032]In drawing 8 (a), the pads 2 and 3 provided on the slider 1 which consists of a transparent substance optically in order to control the state of surfacing of a slider and the information recording medium 11 are formed. In this example, three pads are provided in the slider bottom. The one pad 2 of them is divided into four, and the probe 4 of the pyramid type for near-field-light generating is formed in the center. In this example, the height of four divided small pads which were provided in the pad 2 is designed smaller than the height from the pad 2 whole and the slider bottom of the pad 3. By doing in this way, the size of the probe 4 cannot be caused how but the height from the slider bottom to the pad upper surface can be designed freely. Thereby, the flying height of a slider can be set up arbitrarily. The height of four divided small pads which were provided in the pad 2 is slightly set up highly from the height of the probe 4 like Example 1. Since the height of a small pad can be freely set up according to the shape of a probe, and size, without taking the flying height of a slider into consideration, the flexibility of probe production becomes large.

[0033]Although explained as a probe taking the case of the thing of the shape of drawing 2 (a), the slider shape of Examples 2 and 3 is completely applicable [from drawing 2] in the above-mentioned Examples 2 and 3, similarly about all the other probe shape shown in drawing 6.

[0034]Drawing 9 and drawing 10 are the figures which were shown in drawing 8 from drawing 1 and in which showing the making process of a near field light head.

[0035]First, like drawing 9 (a), the photoresist 40 is applied, exposed and developed on the substrate 1, and it leaves as a mask only the pads 2 and 3 and the portion which produces the probe 4. Next, the mask pattern formed by drawing 9 (a) is transferred to the substrate 1 by the dry etching using argon gas like drawing 9 (b), for example. Next, like drawing 9 (c), after removing the photoresist 40, the protective film 6 which protects the slider bottom and a pad surface is formed by sputtering process etc. Next, a probe is processed into a predetermined form like drawing 9 (d) by etching using the focused ion beam (Focused Ion Beam: call it FIB for short below) 41. In FIB processing, when using gallium ion, for example, accelerating voltage shall be tens of kV and beam current is set to about several 10 pA. The beam size in the converging position of FIB41 at this time is several 10 nm, and is sufficient resolution to produce the probe of this invention. Since the position which irradiates with ion freely is controllable, looking at the secondary electron image acquired by taking the secondary electron image to emit, irradiating with ion the sample which should be processed in FIB processing, various processings are short time and it can carry out easily. It etches in processing of the above-mentioned probe, glaring from the one side face of a substrate first to the central projection which should process ion to a probe through between the pads 2. Thereby, the form of a central projection is processed into the shape of a triangular prism from a rectangular parallelepiped. When producing the probe 13 and 23, finally processing is now. When producing pyramid-shaped probes, such as the probe 4, A substrate is rotated 90 degrees around an axis parallel to the medial axis of a probe, from the direction of the beam in the case of the first etching, and the direction which makes 90 degrees, irradiating with ion through between the pads 2 again, it etches and the shape of a cone is processed eventually. Although all the floor to floor time in

this case is based also on the construction material of a substrate, it is about 10 minutes. By applying such FIB processing from a substrate side, and producing a probe, the height of a pad and the height of a probe are equal in general, and the height of a probe can process them small slightly from the height of a pad. Like drawing 9 (e) after FIB processing, a pad and the other slider bottoms are covered by the photoresist 40, only the surroundings of a probe are exposed, and the metal membrane 5 is formed on a probe. Finally, by the lift-off method, the metal formed on a pad and the other slider bottoms is removed, and production [like] of a near field light head is completed to drawing 9 (f).
[0036]When producing the probe which has the opening shown by 6 from drawing 4, the probe of the state of completed drawing 9 (f) is again irradiated with FIB41 from the side like drawing 10, and a tip end part is excised. The size of the size of an opening is freely changeable by controlling the amount of cuts shown in drawing 10. According to this method, as shown in drawing 10, it becomes flat [the excised tip of a probe] and the height does not exceed the height of a pad. Therefore, the end of the probe can collide with the recording medium 11, and cannot be damaged, and reliability can be improved.. When producing the probe of the special shape shown in drawing 6 (b) and (c), it etches controlling the current beam position according to shape in the case of the FIB processing of drawing 9 (d). Thus, it is a big effect of this processing method using FIB that arbitrary probe shape can be formed by short floor to floor time.
[0037]Drawing 11 is a perspective view adapting the near field light head of this invention of optical recording playback equipment. The disk 43 which consists of the recording-medium board 10 and the recording-medium film 11 is attached to the axis 44 connected with the spindle motor fixed to the base 42, and rotates. Relative motion is carried out to the slider 1 which carries one near field light head of 8 from drawing 2 in this rotational movement. It is fixed to the base 42, the actuator 49 which positions the slider 1 is also, and the arm 50 and the suspension 52 are attached to the flexible region 48. The flexible region 48 revolves around the medial axis, and moves the slider attached at the tip of the suspension 52 to the radial direction of the disk 43. In using a disk with a small tracking pitch, it attaches to the tip part of the arm 50 the actuator 51 which enables positioning still more detailed than the actuator 49. It lets the cable which the connector 46 was connected and was connected to the connector 46 pass in the interface 45 fixed to the base 42, and supply of the power supply for driving this device, the record reproduction command to a device, the input of recorded information, and the output of reproduction information are performed to it. Supply of the laser beam to a near field light head and detection of recorded information, detection of the position gap information from the track of a slider, and detection of a position gap of an object lens and a slider are performed using the optical head 53 fixed to the base, although drawing 12 explains for details. The movable part 54 in which the actuator to which a galvanomirror, an object lens, and an object lens are moved was carried is installed directly under the slider. Although not indicated to the sun at drawing 11, the movable part 54 is followed and moved to the radial direction of the disk 43 by the slider 1 with the actuator to which the whole movable part is moved.
[0038]Next, operation of the above-mentioned optical head 53 and the movable part 54 is explained in detail using drawing 12. After the laser beam generated by the semiconductor laser 55 is changed into a collimated beam with the collimate lens 56, it passes the beam splitter 57 and can change a direction with the galvanomirror 58. The laser beam which was able to change the direction with the galvanomirror 58 is condensed with the object lens 7 on the probe 4, near field light is generated, and record to the recording medium formed on the disk 43 and playback are performed. Although hereafter explained taking the case of the probe 4 (and slider 1 which carries it) shown in drawing 2 (a) as a probe, even if it uses which probe (and slider which carries it) indicated from drawing 2 to drawing 8, the following contents are completely the same. It passes along the object lens 7, a direction can be again changed with the galvanomirror 58, it reflects by the beam splitter 57, and the laser beam which had intensity modulated by the information on a recording medium is led to a detection system. In a detection system, detection of a read signal and the focus of a laser beam and the detection of a position gap of the optical axis direction of the probe 4 which were condensed with the object lens 7, and detection of a position gap of an optic axis and a perpendicular direction are performed. A position gap

of an optic axis, a vertical laser beam focus, and the probe 4, be condensed with the lens 60 and be alike beam splitter 61 -- it condenses with the lens 63 which condenses only to one way, for example, a cylindrical lens, to up to the quadrisection photodetector 64, and the divided laser beam is performed using the focal error detection system called what is called astigmatic method. The quadrisection photodetector 62 performs detection of a gap of the focus of a laser beam, the optic axis of the probe 4, and a perpendicular direction as follows. If the focus of a laser beam carries out a position gap at the radial direction of the probe 4 and the disk 43, imbalance will arise in the sum signal of the detector A of a quadrisection photodetector, and the detector C, and the sum signal of the detector B and the detector D. Therefore, a position gap is detectable if the difference of these sum signals is used. On the other hand, if the focus of a laser beam shifts to the hoop direction of the probe 4 and the disk 43, imbalance will arise in the sum signal of the detector A of a quadrisection photodetector, and the detector B, and the sum signal of the detector C and the detector D. Therefore, a position gap is detectable if the difference of these sum signals is used. With the two-dimensional actuator 59 attached to the surroundings of an object lens, using these position gap signals a position gap of the focus of a laser beam and the optical axis direction of the probe 4, and a position gap of the hoop direction of the disk 43, With the actuator to which inclination of the mirror 58 attached to the galvanomirror 58 is moved. The focus of an object lens can always be doubled with the probe 4, and near field light can be made to generate efficiently by amending a position gap of the radial direction of the focus of a laser beam and the disk 43 of the probe 4. Finally, for example as a recording medium formed on the disk, playback of recorded information is performed using the intensity of the sum signal of all the detectors of the two quadrisection detectors 62 and 64, when using a what is called phase change type recording medium and the concavo-convex recording medium only for playback.

[0039]Next, positioning in this invention and servo technology are explained using drawing 13. In drawing 13, 65 to 71 shows seven in many code tracks formed on the disk. 72 is an address mark group which identifies a track number, differs for every track and detects on which track the probe 4 is located by this mark. The wobble mark 73 and the clock mark 74 are formed in each track. In the case of the record reproduction of information, the probe 4 moves upwards from under a figure in drawing 13. The probe 4 passes through the wobble mark 73 top, after a clock is created through the clock mark 74. When the position of the probe has shifted from the track center, imbalance arises from two continuous wobble marks to a signal, the difference of these signals is taken, and it is considered as a tracking error signal. The actuator 49 is driven according to this error signal (supposing it is attached also in case of actuator 51), and alignment of the probe 4 is carried out to a track center. Since the object lens 7 operates so that the focus of a laser beam may always be located on the probe 4 as mentioned above, the servo of it is followed and carried out to the servo operation of the above [the focus of a laser beam]. After the probe 4 passes through the wobble mark 73 top, it passes through the address mark 72 top, and it goes into up to the Records Department 75 which records information, and record reproduction of information is performed.

[0040]Next, the seek operation to which the probe 4 is moved to the target track is described. In seek operation, the position which should record the information specified from the external control device, and should be reproduced is compared with the position of the actual probe 4 detected by the quadrisection photodetectors 62 and 64 from the system controller 47 of drawing 11. Based on this comparison result, the positioning actuator 49 is driven (supposing it is attached also in case of actuator 51), and the probe 4 is positioned on the predetermined track on a disk. At this time, the object lens 7 so that the focal position of a laser beam and the position of the probe 4 may be in an optical axis direction and a flat surface vertical to an optic axis and may not shift to the hoop direction of a disk, While a servo is carried out with the actuator 59, to the sun, it is not indicated at drawing 12, but it is followed and moved to the slider 1 which carries a probe by the actuator made to move the flexible region 54 whole to the radial direction of a disk. The slider 1 and the flexible region 54 are very lightweight, and can shorten time which seeking takes for this reason just like [usual] a magnetic disk drive.

[0041]Drawing 14 is a figure showing other examples of this invention. Drawing 14 (a) is the example which was accumulated on the slider 1 and the object lens 76 gave. As the lens 76, the lens adapting

diffraction gratings, such as a Fresnel lens besides the lens of the usual curved surface shape, can be used. Drawing 14 (b) is the example in which the semiconductor laser 77 and the photodetector 79 besides the object lens 78 were carried on the slider 1. In this case, about the plane lens using diffraction gratings, such as a Fresnel lens, as the object lens 78, if a surface emission-type laser is used as a semiconductor laser, a device will become very small. In the example of drawing 14 (b), the focus of a laser beam and the mutual alignment of the probe 4 become completely unnecessary, and the optical head parts 53 and 54 indicated to drawing 11 and drawing 12 become unnecessary. If it has such composition, an equipment configuration turns into the completely same composition as the present magnetic disk drive, and can constitute very thin and small optical recording playback equipment.

[0042]Drawing 15 is a figure in which a book shows the example of further others of an invention. Although the old example showed the example for performing detection of information using the catoptric light from a probe, drawing 15 shows the example which uses the transmitted light from a disk. The regenerative signal from the information 12 is condensed on the detector 82 with the object lens 80. When using an optical magnetic recording medium as the optical recording medium 11, it detects by inserting further the element 81 which controls the polarization direction of the transmitted light in front of the detector 82.

[0043]Above, three pads were provided in the bottom of the slider 1, and the one pad 2 of them is divided into four, and has explained the example in which the probe 4 of the pyramid type for near-field-light generating is formed in the center. Like drawing 16, it is also possible to have still easier composition. In drawing 16 (a), the three pads 2 are formed in the bottom of the slider 1. It approaches inside one of pads of it, and the probe 4 of the pyramid type for near-field-light generating is formed. It is possible to use the probe of the shape of a gap to be shown in drawing 6 from drawing 2 as the probe 4. In drawing 16, although the example of the risen [to surface] type slider corresponding to drawing 1 was shown, it is also possible to use the contact type slider of drawing 7. The probe 4 the pad 83 installed by the probe 4 for near-field-light generating approaching like drawing 8 in drawing 16 (b) and for near-field-light generating is formed in common foundation top of one 84, The height of the pad 83 is an example currently designed smaller than the height from the slider bottom of other pad pads 3. In these examples, there is an advantage that the structure of a slider is easy and the production becomes easier.

[0044]

[Effect of the Invention]It is possible to enlarge relative velocity of the optical head which carries out record reproduction of a recording medium and the information, in order to enlarge the transfer rate of information as mentioned above according to this invention, And the additional equipment for detecting the distance of a recording medium and an optical head becomes possible [providing the near field light head of unnecessary small size and lightweight and simple composition, and the optical recording playback equipment using it].

[Translation done.]

TECHNICAL FIELD

[Field of the Invention]Especially this invention relates to the processing method of a near field light head and a near field light head which is super-high recording density and was suitable for enlarging a transfer rate, and an optical information processing device about the processing method of a near field light head and a near field light head, and an optical information processing device.

[Translation done.]

PRIOR ART

[Description of the Prior Art]The optical recording adapting near field light attracts attention as a method of attaining the densification of an optical disk unit in recent years. For example, the tip of an optical fiber is processed into cone shape as indicated from 142 pages of applied physics Letters, 61 volumes, and No. 2 to 144 pages (Applied Physics Lettes, Vol.62, No.2, pp.142-144-1992), The probe which covered except several 10-nm field at the tip with the metaled tunic is produced, this is carried in the precision actuator using a piezo-electric element, a position is controlled, and the example which carried out record reproduction of the recording mark 60 nm in diameter on the multilayer film of platina/cobalt is reported. In the case of this example, the Xia force method which applied atomic force to the distance control of a probe and a recording medium is used, and storage density reaches [square inch] in 45 gigabits /, and can be made into about 20 times of the actual condition. While condensing light with a lens at a minute pinhole in JP,3-171434,A and generating near field light, How to control the distance between said minute pinholes and a recording medium using the atomic force which generates said detailed pinhole between the cantilever and recording medium which were formed at the tip, And a light source, a lens, and the slider that stored minute pinholes are arranged on a medium, exhaust air surfacing of the slider is carried out, and the method of controlling the distance between minute pinholes and a recording medium is devised.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention]It is possible to enlarge relative velocity of the optical head which carries out record reproduction of a recording medium and the information, in order to enlarge the transfer rate of information as mentioned above according to this invention, And the additional equipment for detecting the distance of a recording medium and an optical head becomes possible [providing the near field light head of unnecessary small size and lightweight and simple composition, and the optical recording playback equipment using it].

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]In a light information recording and reproducing device, in order to enlarge the transfer rate of information, it is necessary to enlarge relative velocity of the optical head which carries out record reproduction of a recording medium and the information.
[0004]However, in the first conventional example adapting the Xia force method which applied atomic force to the distance control of a probe and a recording medium of the above. Since it is necessary using a scanning force microscope to control very precisely the distance of a recording medium and an optical head, i.e., a fiber probe, When the disk which recorded information is rotated at high speed, change of the substrate of high frequency and the distance of a probe produced with the eccentricity of a disk cannot be controlled, and there is a problem that a transfer rate cannot be gathered.
[0005]In the conventional example adapting a cantilever, change of capacitance and laser interference measurement are used as a detecting method of displacement of a cantilever, The large-scale optical system other than the irradiation optical system which generates approaching space thru/or the capacitance system of measurement were needed, and there was a problem that a device was enlarged and complicated. In a 3531 to 3533 pages [of applied physics Letters, 68 volumes, and No. 25] (AppliedPhysics Lettes, Vol.68, No.25, pp.3531-3533-1996) example. Although the back of a cantilever is irradiated with a laser beam and the optical-lever method which changes displacement of a cantilever into movement of the light spot on a linear photo-diode, and detects it is used as a detecting method of displacement of a cantilever, The large-scale optical system other than the irradiation optical system which generates approaching space also in this case was needed, and there was a problem that a device was enlarged and complicated.
[0006]In the conventional example which arranges on a medium a light source, a lens, and the slider that stored minute pinholes, many optics, such as a light source and a lens, are carried on the slider. For this reason, the mass of a slider will increase, the flattery performance to the vertical vibration accompanying rotation of a recording medium will deteriorate, and construction of a device will become impossible. Loading of a concrete pinhole, a laser light source, and a lens and a formation method are not indicated by said JP,3-171434,A.
[0007]The purpose of this invention can enlarge relative velocity of the optical head which carries out record reproduction of a recording medium and the information, in order to enlarge the transfer rate of information of the super-high-density optical recording reproduction speed adapting the probe for near-field-light generating. And providing unnecessary small size, the near field light head of lightweight and simple composition, and the optical recording playback equipment using it has the additional equipment for detecting the distance of a recording medium and an optical head.

[Translation done.]

MEANS

[Means for Solving the Problem]The following means were adopted in order to solve an aforementioned problem.
[0009]An optically transparent slider top which carries out relative motion contacting an information recording medium while maintaining an almost fixed interval and rising to surface, A pillar provided on said information recording medium and a field which counters in order to control contact of said slider and said information recording medium thru/or a state of surfacing thru/or a square pillar-shaped pad, Approach and a probe which generates near field light of a minute spot size is formed, Height from said pad, said information recording medium of a slider of said probe, and a field that counters spreads abbreviation etc., and height from said information recording medium of said probe and a field which counters makes it smaller than height from said information recording medium of said pad, and a field which counters. Thereby, an approaching space head is a slider and really formed and a head used with the conventional magnetic disk drive, and small size and a near field light head of lightweight and simple composition with the same performance can be constituted. Small size and since it becomes lightweight, a slider becomes possible [enlarging relative velocity of an optical head which carries out record reproduction of a recording medium and the information].
[0010]In [further again] a tip end part of said probe in forming an opaque thin film, for example, a metal thin film, optically on said pad and said probe in said near field light head ****, When the surface of a portion which had the structure which an object which constitutes said probe has exposed, and has exposed said probe, and the surface of said metal thin film produce a minute opening which becomes the same flat surface substantially, it enables it to generate near field light of minute size.
[0011]It lets a gap of a portion which has arranged said pad section in said near field light head so that said probe may be surrounded, divided said pad section into two or more portions at least further again, and was divided from the pad side pass, By arranging so that looking down at said probe may be possible, it makes it possible to process probe shape into arbitrary cone structures, or to produce a minute opening by irradiating with and etching a particle beam from the side.
[0012]Optical recording playback equipment of super high density can be constituted using a light-receiving means to detect a modulating signal by said near field light head, light source which provides illumination light to said near field light head, optical recording medium, and a recording medium of near field light generated by said near field light head.
[0013]
[Embodiment of the Invention]Hereafter, the example of this invention is described using a drawing.
[0014]Drawing 1 is one example of this invention, and it is the sectional view where drawing 1 (a) met the perspective view of the near field light head of this invention, and drawing 1 (b) met AA of drawing 1 (a).
[0015]In drawing 1 (a), 1 is a slider which consists of a transparent substance optically. In this example, since the case where a semiconductor laser with a wavelength of 780 nm was used as a light source was explained, the construction material of the slider chose quartz, but it is not limited to this. 2 to 3 is the pad provided in order to control the state of surfacing of a slider and the information recording medium

11. In this example, three pads are provided in the slider bottom. The one pad 2 of them is divided into four, and the probe 4 of the pyramid type for near-field-light generating is formed in the center. The probe 4 is coated with the with a number of thickness of 10 nm metal thin film 5 as shown in drawing 1 (b). the thin film 6 for the prevention from wear, for example, a carbon film, resembles the field which counters the recording medium of the pads 2-3 and the other slider, and membranes are formed by about 10 nm in it. In drawing 1 (b), 7 is an object lens for condensing the semiconductor laser beam 8 to the probe 4 for near-field-light generating. The condensed semiconductor laser beam 8 is changed into the near field light 9 of minute size near the tip of the near-field-light generating probe 4. From the recording-medium board 10, as for a slider, 10 nm of numbers surface, it runs, and record of the information 12 to the recording medium 11 formed on the substrate 10 of said near field light 9 and reproduction are performed.
[0016]Here, height h of the probe 5 must be made smaller than height h of the pad 2. As drawing 1 (b) showed, from the recording-medium board 11, only several 10 nm of sliders surface, and run. The upper surface of the pad 2 hits the sliding surface of a slider and the recording-medium board 11. For this reason, when the situation where a slider and a recording-medium board contact during the record reproduction operation by this head occurs, the pad upper surface contacts a recording-medium board. If height h of the probe 4 is larger than height h of the pad 2 at this time, a recording-medium board will contact the end of the probe, and wear of a probe will be caused. In order to prevent this, it is necessary to make h certainly smaller than h. It is necessary it not only to to make h smaller than h, but to make the difference of h and h very small. It is known that the intensity of the near field light 9 will decrease rapidly if the distance from the end of the probe becomes larger than it although the distance from the end of the probe does not change a lot to the size grade of the end of the probe. The size of the end of the probe in the case of this example is several 10 to 100 nm, and when the distance of a probe and a medium becomes large more, the intensity of the near field light 10 will become very small on the recording medium 11. In order for several 10 nm of sliders to surface and to run from a recording medium surface, and to keep the distance of a probe and a medium at 100 from the size of the end of the probe, i.e., several 10, nm or less, It is necessary to make h and h almost the same and to also keep the distance of the end of the probe and a recording medium surface at about several 10 nm at the time of a slider run. For the purpose, the difference of h and h must be controlled by nm order. This point is a big point of this near field light head production, and a manufacturing method is explained in full detail later.
[0017]If the near field light head in which the above probes for approaching space generating were a slider and really formed is used, the head used with the conventional magnetic disk drive, and small size and the near field light head of lightweight and simple composition with the same performance can be constituted. And small size and since it becomes lightweight, a slider can enlarge relative velocity of the optical head which carries out record reproduction of a recording medium and the information, and it becomes possible to improve the transfer rate of information.
[0018]Next, the probe for near-field-light generating used by this example is explained in full detail using drawing 6 from drawing 2.
[0019]The enlarged drawing of the pyramid-shaped probe with which drawing 2 (a) was used by drawing 1, and drawing 2 (b) are the enlarged drawings of the probe of trianglepole shape. In the field (parallel to the polarization direction of the semiconductor laser beam 8) where drawing 2 (c) passes along the middle points B and B of two neighborhoods at the bottom through the vertex of a pyramid in drawing 2 (a), and drawing 2 (b), The sectional view in the field (parallel to the polarization direction of the semiconductor laser beam 8) passing through the middle point C, C, and C of three neighborhoods of a triangular prism is expressed.
[0020]When the probe 4 is formed with quartz, it is [in / drawing 2 (a) / thin film / 5 / which is formed on the probe 4 / metal] selectable in various kinds of things. However, high efficiency is obtained when a certain specific relation between the half width theta of a metaled kind and the vertical angle of the pyramid shown by drawing 2 (c) is. It is condensed near the tip of the probe 4 and the semiconductor laser beam 8 can consider mostly that the wave front is a flat surface. In this case, if the above-

mentioned angle theta and a metaled kind are combined suitably, the surface plasma wave 16 will be excited in the metal thin film 5. A surface plasma wave can be spread also in a tens of nm thin metal membrane, and the semiconductor laser beam changed into the surface plasma wave can be efficiently spread to the end of the probe, and can make the near field light 9 generate at high efficiency. For example, if quartz is used as a probe, when using aluminum as metal, theta uses gold about 42 degrees and theta uses silver about 44 degrees, theta may be about 44 degrees. In drawing 2 (b), since the shape of the probe 13 is a triangular prism, the light collected near the end of the probe is condensed only in a field parallel to the section CCC. things -- a sake -- drawing 2 -- (-- the linear near field light 15 occurs in the case of a), and a thing. High efficiency will be obtained if the half width theta of the vertical angle and the relation of the kind of metal 14 are set up the same with having explained above also in shape like drawing 2 (b).
[0021]Production is easy although the size in particular of the probes 4 and 13 is not limited, If it, for example, considers that all the laser beams are effectively condensed by the probe in consideration of the condensing spot being about 1.3 micrometers when the laser beam 8 with a wavelength of 780 nm is condensed with the object lens 7 of the numerical aperture 0.6, For example, in the case of drawing 2 (a), it is desirable for one side of the square at the bottom of a pyramid to be 3 to 4 micrometers. Although it is desirable to be referred to as about 3 to 4 micrometers as for a length of two sides parallel to the section CCC in the case of drawing 2 (b), two sides vertical to the section CCC choose various values with the spot size of the near field light 15.
[0022]Drawing 3 is an example in case the probe 17 is conical shape. If the half width theta of a conic vertical angle and the relation of the kind of metal 18 formed on a probe satisfy the above specific conditions also in this case, it is possible to generate the near field light 10 at high efficiency.
[0023]Drawing 4 is another example of the probe for near-field-light generating. The probe with which the tip end part of the pyramid-shaped probe 5 with which drawing 4 (a) was shown by drawing 2 (a) was excised, The probe and drawing 4 (c) from which the tip end part of the triangular prism shape 13 shown by drawing 2 (b) was excised drawing 4 (b), In the field (parallel to the polarization direction of the semiconductor laser beam 8) which passes along four points of the middle points D and D of two sides of the quadrangle of the upper surface of a truncated four-sided pyramid, and the middle points D and D of two sides of a quadrangle at the bottom in drawing 4 (a), and drawing 4 (b), The sectional view in the field (parallel to the polarization direction of the semiconductor laser beam 8) which passes along four points of the middle points E and E of two sides of the quadrangle of the upper surface on the upper surface of a probe and the middle points E and E of two sides of a quadrangle at the bottom is expressed.

[0024]In drawing 4 (a), as for the probe 19, the tip of a pyramid is excised and the opening 21 is formed. In the probe with which the opening is formed, it is used as a light-shielding film of the semiconductor laser beam 8 by which the opaque thin film 20, for example, a metal membrane, was optically condensed with the object lens formed in the probe surface. In this case, the size of the near field light 22 used for record reproduction becomes what the light to the metal membrane sank into size d of the opening 21, and applied the depth. If the processing method explained in full detail later is used, an opening with a size of about 20 nm can be formed at the minimum. As metal for protection from light, various metal, such as gold, silver, platinum, aluminum, and chromium, is used. Light with a wavelength [to these metal] of 780 nm sinks in, and typically, the depth is 10 to 20 nm, as mentioned above can form a minimum of about 40-nm near field light spot. In drawing 4 (b), the shape of the probe 23 is a triangular prism, and since it is a rectangle also with long and slender shape of the opening 25, the linear near field light 26 occurs. In this case, although the size of the near field light in the section EEEE is the same as the case of drawing 4 (a), it is freely selectable by choosing the length of the neighborhood with a longer rectangle in the size of the section EEEE and a perpendicular direction.
[0025]If the value of the vertical angle phi of the probe shown by drawing 4 (c) is made into about about 30 to 60 degrees, the probe of high transmission efficiency will be obtained. If phi is too small, the length of the taper part of a probe will become large. The light which generally spreads space will not be able to be spread in a field smaller than the size about the wavelength of light, but much light power will

be absorbed by the metal membranes 20 thru/or 24 in the example of drawing 4 (c). For this reason, transmission efficiency becomes small. On the other hand, if phi becomes large too much, almost all lights will be reflected from a probe. Therefore, in order that the value of phi may press down leakage **** of the light to a metal membrane and may press down reflection, it is desirable to use the range of the suitable above-mentioned value.

[0026]Production is easy although the size in particular of the probes 19 and 23 is not limited, If it, for example, considers that all the laser beams are effectively condensed by the probe in consideration of the condensing spot being about 1.3 micrometers when the laser beam 8 with a wavelength of 780 nm is condensed with the object lens 7 of the numerical aperture 0.6, For example, in the case of drawing 4 (a), it is desirable for one side of the square at the bottom of a pyramid to be 3 to 4 micrometers. Although it is desirable to be referred to as about 3 to 4 micrometers as for a length of two sides parallel to the section EEEE in the case of drawing 4 (b), two sides vertical to the section EEEE choose various values with the spot size of the near field light 26, as stated above.

[0027]The probe 27 is conical shape and drawing 5 is an example of a forming [the neighborhood of the peak is excised and / the circular opening 29] case. Also in this case, the size of the near field light 30 can become what the light to the light-shielding film 28 sank into the size of the opening 29, and applied the depth to it, and can choose size of about a minimum of 40 nm. Like the case of drawing 4 (c) mentioned above, if the size of the half width phi of a conic vertical angle is made into about 30 to 60 degrees, it can acquire high transmission efficiency.

[0028]In the case of the probe which has an opening like the probes 19, 23, and 27, research which acquires the further high transmission efficiency is done about the probe produced by carrying out chemical etching of the optical fiber. For example, to 2614 pages (Applied physics Letters, Vol.69, No.19, pp.2612-2614-1996), from 2612 pages of applied physics Letters, the 69th volume, and No. 19 like drawing 6 (b), The vertical angle of the probe 31 is changed into two steps, the vertical angle of the portion of a root is small, and leakage **** of the light to the metal membrane 32 is pressed down by enlarging the vertical angle of the portion at a tip, and the reflection from the probe 31 is pressed down, and it is indicated that a probe with high transmission efficiency can be obtained. Also in this invention, if the processing method mentioned later is used, a probe with high transmission efficiency like drawing 6 (b) can be obtained easily. To 1758 pages (Applied physics Letters, Vol.71, No.13, pp.1756-1758-1997), from 1756 pages of applied physics Letters, the 71st volume, and No. 13, like drawing 6 (c), It is indicated by by making shape of the probe 35 unsymmetrical to the center line of a probe, and exciting a surface plasma wave that a probe with high transmission efficiency can be obtained. Also in this invention, if the processing method mentioned later is used, a probe with high transmission efficiency like drawing 6 (c) can be obtained easily.

[0029]Drawing 7 is the second example of this invention adapting a contact type slider. It is the sectional view where drawing 7 (a) met the perspective view of the near field light head of this example, and drawing 7 (b) met FF of drawing 7 (a).

[0030]In drawing 7 (a), the pad 2 provided in order to control the contact state of the slider 1 and the information recording medium 11 is formed on the slider 1 which consists of a transparent substance optically. In the example of drawing 1, although three pads were provided in the slider bottom, only the pad 2 divided into four is formed at this example. The probe 4 of the pyramid type for near-field-light generating is formed in the center of the pad 2. The probe 4 is coated with the with a number of thickness of 10 nm metal thin film 5 as shown in drawing 7 (b). the thin film 6 for the prevention from wear, for example, a carbon film, resembles the field which counters the recording medium of the pad 2 and the other slider, and membranes are formed by about 10 nm in it. Although drawing 7 (b) showed the example using a material separate as the metal thin film 5 and the thin film 6 for the prevention from wear, Since the paragraph of 6 described the excitation characteristic of the surface plasma wave from drawing 4 which has an opening again in the case of the probe described as abrasion resistance by the paragraph of 3 from drawing 2 without an opening, in the case of a probe, it is the material with which it can be satisfied of both protection-from-light characteristics, for example, a chromium film, It is also possible to cover the slider bottom and a probe surface. Then, production processes become still easier.

In a recording medium surface, the several nanometers carbon film 39 for the prevention from wear is formed, and several nanometers lubricant of polymers is too applied on it. The abrasion resistance of the recording medium 11 is raised by this carbon film and lubricant. The slider 1 runs contacting the recording-medium board 10, and record of the information 12 to the recording medium 11 formed on the substrate 10 of said near field light 9 and reproduction are performed.
[0031]Drawing 8 is the third example of this invention which used the risen [to surface] type slider. It is the sectional view where drawing 8 (a) met the perspective view of the near field light head of this example, and drawing 8 (b) met GG of drawing 8 (a).
[0032]In drawing 8 (a), the pads 2 and 3 provided on the slider 1 which consists of a transparent substance optically in order to control the state of surfacing of a slider and the information recording medium 11 are formed. In this example, three pads are provided in the slider bottom. The one pad 2 of them is divided into four, and the probe 4 of the pyramid type for near-field-light generating is formed in the center. In this example, the height of four divided small pads which were provided in the pad 2 is designed smaller than the height from the pad 2 whole and the slider bottom of the pad 3. By doing in this way, the size of the probe 4 cannot be caused how but the height from the slider bottom to the pad upper surface can be designed freely. Thereby, the flying height of a slider can be set up arbitrarily. The height of four divided small pads which were provided in the pad 2 is slightly set up highly from the height of the probe 4 like Example 1. Since the height of a small pad can be freely set up according to the shape of a probe, and size, without taking the flying height of a slider into consideration, the flexibility of probe production becomes large.
[0033]Although explained as a probe taking the case of the thing of the shape of drawing 2 (a), the slider shape of Examples 2 and 3 is completely applicable [from drawing 2] in the above-mentioned Examples 2 and 3, similarly about all the other probe shape shown in drawing 6.
[0034]Drawing 9 and drawing 10 are the figures which were shown in drawing 8 from drawing 1 and in which showing the making process of a near field light head.
[0035]First, like drawing 9 (a), the photoresist 40 is applied, exposed and developed on the substrate 1, and it leaves as a mask only the pads 2 and 3 and the portion which produces the probe 4. Next, the mask pattern formed by drawing 9 (a) is transferred to the substrate 1 by the dry etching using argon gas like drawing 9 (b), for example. Next, like drawing 9 (c), after removing the photoresist 40, the protective film 6 which protects the slider bottom and a pad surface is formed by sputtering process etc. Next, a probe is processed into a predetermined form like drawing 9 (d) by etching using the focused ion beam (Focused Ion Beam: call it FIB for short below) 41. In FIB processing, when using gallium ion, for example, accelerating voltage shall be tens of kV and beam current is set to about several 10 pA. The beam size in the converging position of FIB41 at this time is several 10 nm, and is sufficient resolution to produce the probe of this invention. Since the position which irradiates with ion freely is controllable, looking at the secondary electron image acquired by taking the secondary electron image to emit, irradiating with ion the sample which should be processed in FIB processing, various processings are short time and it can carry out easily. It etches in processing of the above-mentioned probe, glaring from the one side face of a substrate first to the central projection which should process ion to a probe through between the pads 2. Thereby, the form of a central projection is processed into the shape of a triangular prism from a rectangular parallelepiped. When producing the probe 13 and 23, finally processing is now. When producing pyramid-shaped probes, such as the probe 4, A substrate is rotated 90 degrees around an axis parallel to the medial axis of a probe, from the direction of the beam in the case of the first etching, and the direction which makes 90 degrees, irradiating with ion through between the pads 2 again, it etches and the shape of a cone is processed eventually. Although all the floor to floor time in this case is based also on the construction material of a substrate, it is about 10 minutes. By applying such FIB processing from a substrate side, and producing a probe, the height of a pad and the height of a probe are equal in general, and the height of a probe can process them small slightly from the height of a pad. Like drawing 9 (e) after FIB processing, a pad and the other slider bottoms are covered by the photoresist 40, only the surroundings of a probe are exposed, and the metal membrane 5 is formed on a probe. Finally, by the lift-off method, the metal formed on a pad and the other slider bottoms is

removed, and production [like] of a near field light head is completed to drawing 9 (f).
[0036]When producing the probe which has the opening shown by 6 from drawing 4, the probe of the state of completed drawing 9 (f) is again irradiated with FIB41 from the side like drawing 10, and a tip end part is excised. The size of the size of an opening is freely changeable by controlling the amount of cuts shown in drawing 10. According to this method, as shown in drawing 10, it becomes flat [the excised tip of a probe] and the height does not exceed the height of a pad. Therefore, the end of the probe can collide with the recording medium 11, and cannot be damaged, and reliability can be improved. When producing the probe of the special shape shown in drawing 6 (b) and (c), it etches controlling the current beam position according to shape in the case of the FIB processing of drawing 9 (d). Thus, it is a big effect of this processing method using FIB that arbitrary probe shape can be formed by short floor to floor time.
[0037]Drawing 11 is a perspective view adapting the near field light head of this invention of optical recording playback equipment. The disk 43 which consists of the recording-medium board 10 and the recording-medium film 11 is attached to the axis 44 connected with the spindle motor fixed to the base 42, and rotates. Relative motion is carried out to the slider 1 which carries one near field light head of 8 from drawing 2 in this rotational movement. It is fixed to the base 42, the actuator 49 which positions the slider 1 is also, and the arm 50 and the suspension 52 are attached to the flexible region 48. The flexible region 48 revolves around the medial axis, and moves the slider attached at the tip of the suspension 52 to the radial direction of the disk 43. In using a disk with a small tracking pitch, it attaches to the tip part of the arm 50 the actuator 51 which enables positioning still more detailed than the actuator 49. It lets the cable which the connector 46 was connected and was connected to the connector 46 pass in the interface 45 fixed to the base 42, and supply of the power supply for driving this device, the record reproduction command to a device, the input of recorded information, and the output of reproduction information are performed to it. Supply of the laser beam to a near field light head and detection of recorded information, detection of the position gap information from the track of a slider, and detection of a position gap of an object lens and a slider are performed using the optical head 53 fixed to the base, although drawing 12 explains for details. The movable part 54 in which the actuator to which a galvanomirror, an object lens, and an object lens are moved was carried is installed directly under the slider. Although not indicated to the sun at drawing 11, the movable part 54 is followed and moved to the radial direction of the disk 43 by the slider 1 with the actuator to which the whole movable part is moved.
[0038]Next, operation of the above-mentioned optical head 53 and the movable part 54 is explained in detail using drawing 12. After the laser beam generated by the semiconductor laser 55 is changed into a collimated beam with the collimate lens 56, it passes the beam splitter 57 and can change a direction with the galvanomirror 58. The laser beam which was able to change the direction with the galvanomirror 58 is condensed with the object lens 7 on the probe 4, near field light is generated, and record to the recording medium formed on the disk 43 and playback are performed. Although hereafter explained taking the case of the probe 4 (and slider 1 which carries it) shown in drawing 2 (a) as a probe, even if it uses which probe (and slider which carries it) indicated from drawing 2 to drawing 8, the following contents are completely the same. It passes along the object lens 7, a direction can be again changed with the galvanomirror 58, it reflects by the beam splitter 57, and the laser beam which had intensity modulated by the information on a recording medium is led to a detection system. In a detection system, detection of a read signal and the focus of a laser beam and the detection of a position gap of the optical axis direction of the probe 4 which were condensed with the object lens 7, and detection of a position gap of an optic axis and a perpendicular direction are performed. A position gap of an optic axis, a vertical laser beam focus, and the probe 4, be condensed with the lens 60 and be alike beam splitter 61 -- it condenses with the lens 63 which condenses only to one way, for example, a cylindrical lens, to up to the quadrisection photodetector 64, and the divided laser beam is performed using the focal error detection system called what is called astigmatic method. The quadrisection photodetector 62 performs detection of a gap of the focus of a laser beam, the optic axis of the probe 4, and a perpendicular direction as follows. If the focus of a laser beam carries out a position gap at the

radial direction of the probe 4 and the disk 43, imbalance will arise in the sum signal of the detector A of a quadrisection photodetector, and the detector C, and the sum signal of the detector B and the detector D. Therefore, a position gap is detectable if the difference of these sum signals is used. On the other hand, if the focus of a laser beam shifts to the hoop direction of the probe 4 and the disk 43, imbalance will arise in the sum signal of the detector A of a quadrisection photodetector, and the detector B, and the sum signal of the detector C and the detector D. Therefore, a position gap is detectable if the difference of these sum signals is used. With the two-dimensional actuator 59 attached to the surroundings of an object lens, using these position gap signals a position gap of the focus of a laser beam and the optical axis direction of the probe 4, and a position gap of the hoop direction of the disk 43, With the actuator to which inclination of the mirror 58 attached to the galvanomirror 58 is moved. The focus of an object lens can always be doubled with the probe 4, and near field light can be made to generate efficiently by amending a position gap of the radial direction of the focus of a laser beam and the disk 43 of the probe 4. Finally, for example as a recording medium formed on the disk, playback of recorded information is performed using the intensity of the sum signal of all the detectors of the two quadrisection detectors 62 and 64, when using a what is called phase change type recording medium and the concavo-convex recording medium only for playback.

[0039]Next, positioning in this invention and servo technology are explained using drawing 13. In drawing 13, 65 to 71 shows seven in many code tracks formed on the disk. 72 is an address mark group which identifies a track number, differs for every track and detects on which track the probe 4 is located by this mark. The wobble mark 73 and the clock mark 74 are formed in each track. In the case of the record reproduction of information, the probe 4 moves upwards from under a figure in drawing 13. The probe 4 passes through the wobble mark 73 top, after a clock is created through the clock mark 74. When the position of the probe has shifted from the track center, imbalance arises from two continuous wobble marks to a signal, the difference of these signals is taken, and it is considered as a tracking error signal. The actuator 49 is driven according to this error signal (supposing it is attached also in case of actuator 51), and alignment of the probe 4 is carried out to a track center. Since the object lens 7 operates so that the focus of a laser beam may always be located on the probe 4 as mentioned above, the servo of it is followed and carried out to the servo operation of the above [the focus of a laser beam]. After the probe 4 passes through the wobble mark 73 top, it passes through the address mark 72 top, and it goes into up to the Records Department 75 which records information, and record reproduction of information is performed.

[0040]Next, the seek operation to which the probe 4 is moved to the target track is described. In seek operation, the position which should record the information specified from the external control device, and should be reproduced is compared with the position of the actual probe 4 detected by the quadrisection photodetectors 62 and 64 from the system controller 47 of drawing 11. Based on this comparison result, the positioning actuator 49 is driven (supposing it is attached also in case of actuator 51), and the probe 4 is positioned on the predetermined track on a disk. At this time, the object lens 7 so that the focal position of a laser beam and the position of the probe 4 may be in an optical axis direction and a flat surface vertical to an optic axis and may not shift to the hoop direction of a disk, While a servo is carried out with the actuator 59, to the sun, it is not indicated at drawing 12, but it is followed and moved to the slider 1 which carries a probe by the actuator made to move the flexible region 54 whole to the radial direction of a disk. The slider 1 and the flexible region 54 are very lightweight, and can shorten time which seeking takes for this reason just like [usual] a magnetic disk drive.

[0041]Drawing 14 is a figure showing other examples of this invention. Drawing 14 (a) is the example which was accumulated on the slider 1 and the object lens 76 gave. As the lens 76, the lens adapting diffraction gratings, such as a Fresnel lens besides the lens of the usual curved surface shape, can be used. Drawing 14 (b) is the example in which the semiconductor laser 77 and the photodetector 79 besides the object lens 78 were carried on the slider 1. In this case, about the plane lens using diffraction gratings, such as a Fresnel lens, as the object lens 78, if a surface emission-type laser is used as a semiconductor laser, a device will become very small. In the example of drawing 14 (b), the focus of a laser beam and the mutual alignment of the probe 4 become completely unnecessary, and the optical

head parts 53 and 54 indicated to drawing 11 and drawing 12 become unnecessary. If it has such composition, an equipment configuration turns into the completely same composition as the present magnetic disk drive, and can constitute very thin and small optical recording playback equipment.
[0042]Drawing 15 is a figure in which a book shows the example of further others of an invention. Although the old example showed the example for performing detection of information using the catoptric light from a probe, drawing 15 shows the example which uses the transmitted light from a disk. The regenerative signal from the information 12 is condensed on the detector 82 with the object lens 80. When using an optical magnetic recording medium as the optical recording medium 11, it detects by inserting further the element 81 which controls the polarization direction of the transmitted light in front of the detector 82.
[0043]Above, three pads were provided in the bottom of the slider 1, and the one pad 2 of them is divided into four, and has explained the example in which the probe 4 of the pyramid type for near-field-light generating is formed in the center. Like drawing 16, it is also possible to have still easier composition. In drawing 16 (a), the three pads 2 are formed in the bottom of the slider 1. It approaches inside one of pads of it, and the probe 4 of the pyramid type for near-field-light generating is formed. It is possible to use the probe of the shape of a gap to be shown in drawing 6 from drawing 2 as the probe 4. In drawing 16, although the example of the risen [to surface] type slider corresponding to drawing 1 was shown, it is also possible to use the contact type slider of drawing 7. The probe 4 the pad 83 installed by the probe 4 for near-field-light generating approaching like drawing 8 in drawing 16 (b) and for near-field-light generating is formed in common foundation top of one 84, The height of the pad 83 is an example currently designed smaller than the height from the slider bottom of other pad pads 3. In these examples, there is an advantage that the structure of a slider is easy and the production becomes easier.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a figure showing the example of the 1st near field light head of this invention, and as for (a), it is a perspective view and (b) is a sectional view.
[Drawing 2]It is a figure showing an example of the probe used by the near field light head, and, as for (a) and (b), a perspective view and (c) are sectional views.
[Drawing 3]The perspective view showing other examples of the probe used by the near field light head.

[Drawing 4]It is a figure showing other examples of the probe used by the near field light head, and, as for (a) and (b), a perspective view and (c) are sectional views.
[Drawing 5]The perspective view showing other examples of the probe used by the near field light head.

[Drawing 6]The sectional view showing the semiconductor laser probe used by this invention.
[Drawing 7]It is a figure showing the 2nd example of this invention using a contact type slider, and as for (a), it is a perspective view and (b) is a sectional view.
[Drawing 8]It is a figure showing the 3rd example of this invention, and as for (a), it is a perspective view and (b) is a sectional view.
[Drawing 9]The figure showing the making process of various near field light heads shown by drawing 8 from drawing 1.
[Drawing 10]Drawing 5, the figure showing the making process of the near field light head of 6.
[Drawing 11]The perspective view adapting the near field light head of this invention of optical recording playback equipment.
[Drawing 12]The figure showing the details of the optical head part used by drawing 11.
[Drawing 13]The figure explaining the servo operation in the optical recording playback equipment of this invention.
[Drawing 14]The figure showing other examples of the near field light head of this invention.
[Drawing 15]The figure showing other examples of the optical recording playback equipment of this invention.
[Drawing 16]The figure showing the 4th example of the slider of this invention.
[Description of Notations]
1 [-- A probe, 5 / -- Metal thin film,] -- A slider, 2 -- A pad, 3 -- A pad, 4 6 [-- Near field light,] -- The thin film for the prevention from wear, 7 -- An object lens, 8 -- A semiconductor laser beam, 9 10 [-- A probe, 14 / -- Metal thin film,] -- A substrate, 11 -- A recording medium, 12 -- Recorded information, 13 15 [-- Metal thin film,] -- Near field light, 16 -- A surface plasma wave, 17 -- A probe, 18 19 [-- Near field light, 23 / -- Probe,] -- A probe, 20 -- A light-shielding film, 21 -- An opening, 22 24 [-- A probe, 28 / -- Light-shielding film,] -- A light-shielding film, 25 -- An opening, 26 -- Near field light, 27 29 [-- A light-shielding film, 33 / -- Opening,] -- An opening, 30 -- Near field light, 31 -- A probe, 32 34 [-- An opening, 38 / -- Near field light,] -- Near field light, 35 -- A probe, 36 -- A light-shielding film, 37 39 [-- Base,] -- The thin film for wear prevention, 40 -- Photoresist, 41 -- FIB, 42 43 [--

Connector,] -- A disk, 44 -- An axis, 45 -- An interface, 46 47 -- A system controller, 48 -- A flexible region, 49 -- Actuator, 50 [-- An optical head, 54 / -- An optical head flexible region, 55 / -- A semiconductor laser, 56 / -- A collimate lens, 57 / -- A beam splitter, 58 / -- A galvanomirror, 59 / -- Two-dimensional actuator,] -- An arm, 51 -- An actuator, 52 -- A suspension, 53 60 [-- Cylindrical lens,] -- A lens, 61 -- A beam splitter, 62 -- A quadrisection photodetector, 63 64 -- A quadrisection photodetector, 65, 66, 67, 68, 69, 70, 71 -- Code track, 72 [-- An information storage part, 76 / -- An object lens, 77 / -- A semiconductor laser, 78 / -- An object lens, 79 / -- A photodetector, 80 / -- An object lens, 81 / -- A polarization controlling element, 82 / -- A photodetector, 83 / -- A pad, 84 / -- Foundation.] -- An address mark, 73 -- A wobble mark, 74 -- A clock mark, 75

[Translation done.]

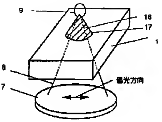
* NOTICES *

`JPO and INPIT are not responsible for any damages caused by the use of this translation.`

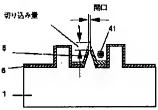
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 3]
図3

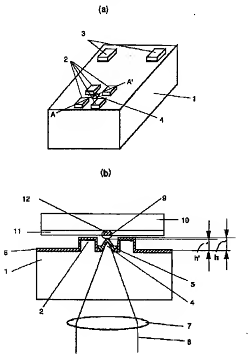


[Drawing 10]
図10



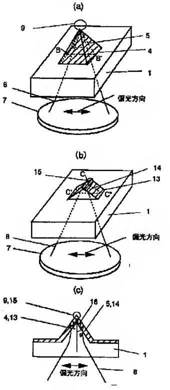
[Drawing 1]

図1



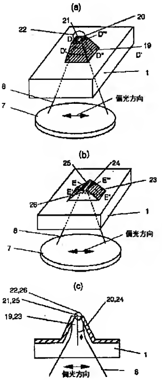
[Drawing 2]

図2



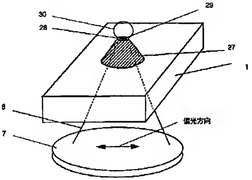
[Drawing 4]

図4



[Drawing 5]

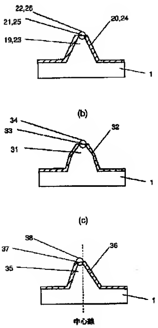
図5



[Drawing 6]

図6

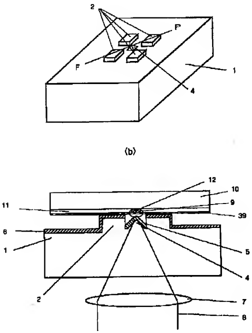
(a)



[Drawing 7]

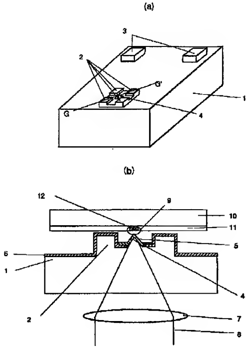
図7

(a)



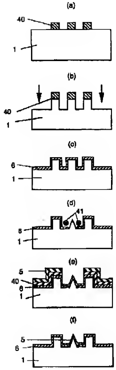
[Drawing 8]

図8



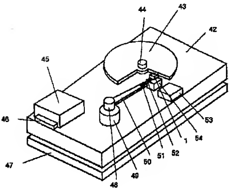
[Drawing 9]

図9



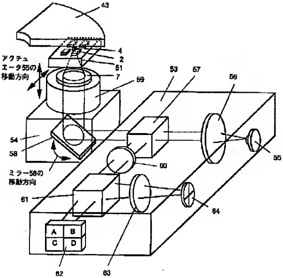
[Drawing 11]

図11



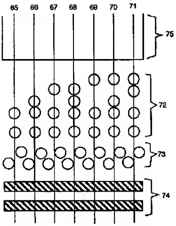
[Drawing 12]

図12

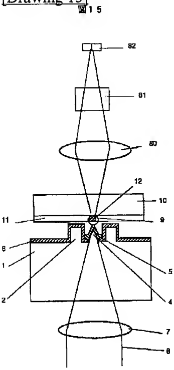


[Drawing 13]

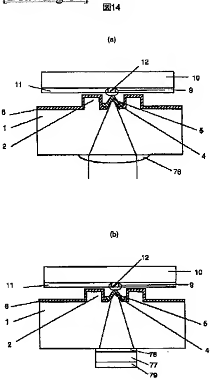
図13



[Drawing 15]



[Drawing 14]



[Drawing 16]

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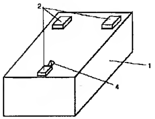
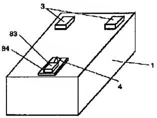
(a)



(b)



[Translation done.]

CORRECTION OR AMENDMENT

[Kind of official gazette]Printing of amendment by the regulation of 2 of Article 17 of Patent Law
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101
[FI]

G11B 7/135 Z

7/09 D

7/12

7/22

21/21 E

101 P
[Written amendment]
[Filing date]October 15, Heisei 14 (2002.10.15)
[Amendment 1]
[Document to be Amended]Specification
[Item(s) to be Amended]Claim
[Method of Amendment]Change
[Proposed Amendment]

[Claim(s)]
[Claim 1]An optically transparent slider which carries out relative motion contacting an information recording medium while maintaining an almost fixed interval, A pillar-shaped pad which is provided on a field of said information recording medium and said slider which counters, and controls contact of said slider and said information recording medium, or a state of surfacing, A near field light head, wherein it has a probe of cone shape which generates near field light of a minute spot size, and said pad and said probe approach and are formed.
[Claim 2]The near field light head according to claim 1 to which height of said probe is characterized by being lower than height of said pad.
[Claim 3]The near field light head according to claim 2, wherein an opaque thin film is optically formed on said probe.
[Claim 4]The near field light head according to claim 3, wherein said thing [that an opaque thin film is metal optically].
[Claim 5]The near field light head according to claim 4 arranging so that said pad may surround said probe.
[Claim 6]The near field light head according to claim 5 characterized by arranging said pad and said probe so that it may let a gap of a portion which said pad is divided into two or more portions at least, and was divided pass and may look down at said probe.
[Claim 7]The near field light head according to claim 5, wherein it has further the opening which a structure of said probe exposed in a tip end part of said probe and said opening and the surface of said metal thin film have become it at the same flat surface mostly.

[Translation done.]